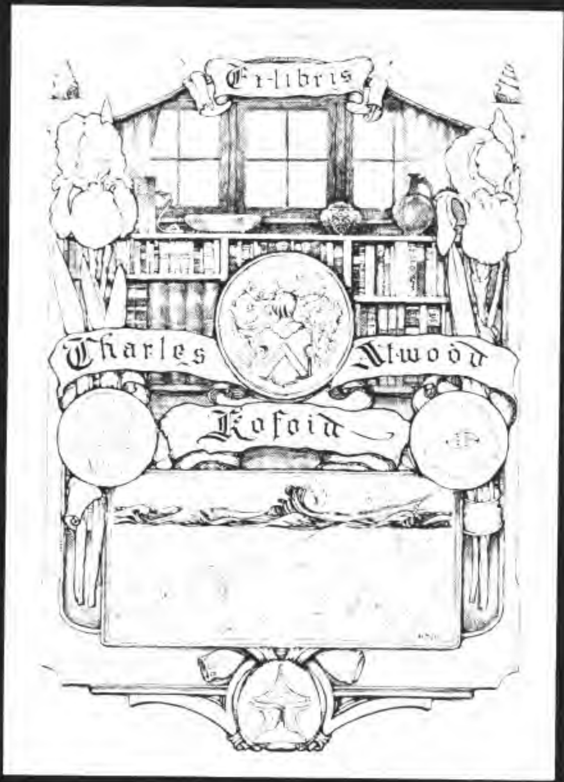
RESEARCHES ON TUBERCULOSIS

THE WEBER-PARKES PRIZE ESSAY

1897

ARTHUR RANSOME M.D., F.R.S.



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THE WEBER-PARKES PRIZE ESSAY

1897

BY

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1898

PREFACE

THE first award of the Weber-Parkes Prize was made in October 1897, and the subject for the Essay proposed by the Adjudicators was:—

'The Means, Prophylactic or Curative, deemed by the Author to have value in the control of Tuberculosis, especial regard being had to their application to Human Tuberculosis.'

It was further stated that

'The Essay must be based on original work and observations (experimental or other) of the author, and must include a detailed exposition of the methods employed and their mode of application.'

The following regulations had to be complied with:—

'10. That the essays be type-written.

'11. That each essay bear a motto, selected by the writer, who shall insert his name within a sealed envelope having the motto on the cover; the envelope being transmitted with the essay to the Registrar, who shall return the unsuccessful essays to their authors.'

Permission to publish the successful Essay has now been granted by the College of Physicians, but, owing to the obligation to exclude from the original document whatever might

serve as a clue to the authorship, it has been necessary, in preparing it for publication, to make certain modifications, such as inserting names of coadjutors, references to previous publications, &c.

Owing to the freedom with which these references may now be made, it has become unnecessary to give the Appendices to the original Essay, and it is possible to omit certain portions of the text, which have been treated at length in other publications. References to these papers are now made in the course of the Essay.

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RESEARCHES ON TUBERCULOSIS

CHAPTER I

INTRODUCTORY AND STATISTICAL

ON THE PROPHYLACTIC AND CURATIVE TREATMENT OF TUBERCULOSIS

At the outset of an essay on the above subject it is needful to point out the limits within which it must be confined. The subject is too vast to be treated at length: some curtailment is essential.

It may be assumed that, in this essay, the results of the observation of the essayist himself are what are chiefly required: therefore, without wishing to attribute to them an undue importance, those researches will be mainly dwelt upon which he has himself carried out; and only in the case of disputed points will the evidence of others be referred to at any length.

On some subjects indeed it will be necessary to recall the discoveries of different observers; but concerning these it will not be desirable to enter into detail. They will be recorded as briefly as possible.

In order still further to shorten the paper, the results only of several of the researches which I have carried out will be given in the text; the details will now, in these cases, be referred to in other publications. In the original essay, they were given, without reference, in several appendices.

OUTLINE OF WORK

Before attempting to point out 'the means, prophylactic or curative,' that may be of use 'in the control of tuberculosis,' much preliminary work must be done, in order to afford a firm basis for our conclusions. I propose to consider this part of the subject under the following heads:—

a. The past and present prevalence of the disease in this country, and its fatality.

b. The distribution of the disease, in nations and in local areas.

c. The natural history of the bacillus of tubercle; its nature; its habits, forms, products, degrees of virulence; and the influence of external conditions upon its growth and infective power.

d. Bodily predisposition, natural or acquired.

e. The channels and sources of infection.

f. The conditions and limits of the power of infection.

When we have sufficiently discussed these several subjects, we may perhaps have an adequate foundation for the consideration of

g. Preventive and prophylactic measures.

h and *j.* The direct and medicinal treatment of the disease.

THE PAST AND PRESENT PREVALENCE OF TUBERCULOSIS

The data for determining this question are somewhat imperfect, even those afforded by the returns of the Registrar-General; yet they must be used for lack of better material. As Dr. Straus remarks ('La Tuberculose et son Bacille,' p. lx.), 'La Statistique, malgré ses imperfections, démeure encore le meilleur élément d'enquête.' Notwithstanding, therefore, the many defects of the registers of deaths, and of the causes of deaths, it behoves us to make the best of the imperfect data at our disposal. Only thus can we ascertain our position in regard to the prevalence of tuberculosis, and its distribution in the past and at the present time.

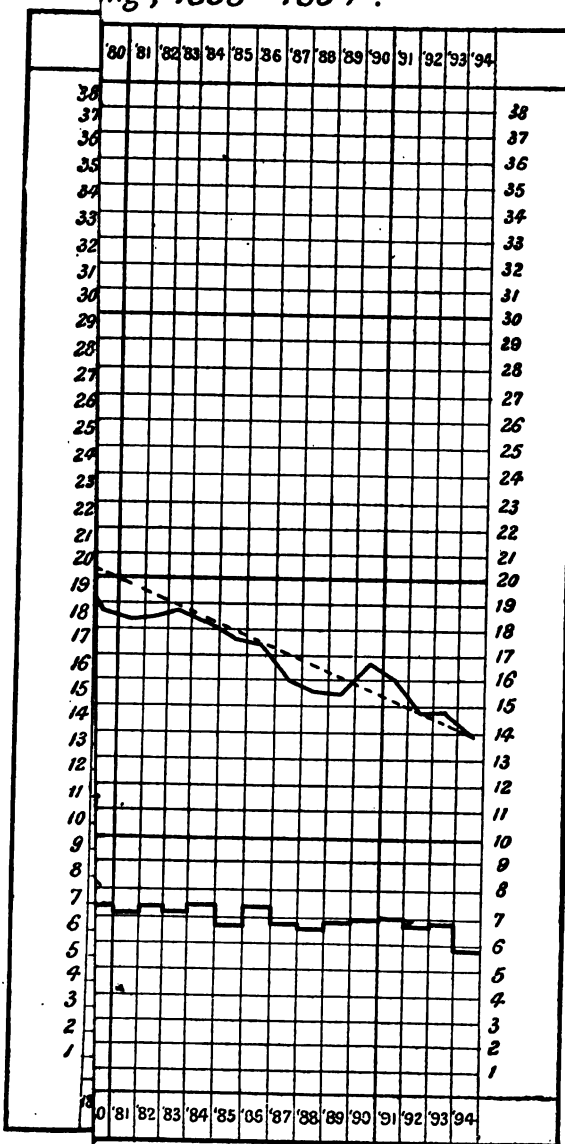
Inquiry I.—I have accordingly made a comparison between the number of deaths from phthisis and the population in England and Wales for each year since returns of these facts were first made—namely, in 1838.

From these calculations I have constructed the following chart, which has been kindly verified by Dr. Tatham, the Medical Officer to the Registrar-General. On this chart are shown, graphically, the rates of mortality, from phthisis, per 10,000 of the population, from the year 1838 to 1895; four years only, from 1843 to 1846, being omitted, as the causes of death were not given in those years.

From this chart it may be perceived at a glance that an enormous decline has taken place in the disease during the last 58 years. In 1838 the phthisis rate per 10,000 was over 38; in 1895, it was nearly 14. In other words, the disease had diminished by nearly two-thirds.

A straight line drawn from the highest to the lowest point of the

ing, 1838 - 1894.



curve of the disease shows that its decline has been remarkably steady and generally regular; moreover, a mathematician would judge that the rate of its diminution has been a slightly increasing one. We may further remark that, if phthisis diminish at the same rate during another thirty years, it will have entirely disappeared by the end of that period.

This decline in the disease is especially interesting to us in view of its probable causes, which we are presently to consider. Without in any way wishing to prejudge the question, the fact may be pointed out that the first great drop in the phthisis rate took place in the decade 1840–50, about the time that serious attention began to be given to sanitary reforms, and especially to land drainage. It then remained scarcely reduced for about seventeen years; but from 1867 to 1895 it has been steadily on the decline. It is in this latter period that most of the great sanitary works have been carried out in this country. It may be that we owe to these ameliorating influences such a regular and substantial diminution of the disease. The only sources of fallacy that can be discovered in these figures are, first, the uncertainty of diagnosis, especially in the earlier periods of the registration of the causes of death; and, second, the acknowledged longer duration of phthisis in the later years.

If, in former days, more cases of bronchitis or broncho-pneumonia were mistaken for phthisis, then these mistaken cases may have raised the apparent rates of mortality of the latter disease.

Again, in more recent years, the extension of the average duration of its progress, before it ended in death, might for a time have postponed the appearance of these deaths in the register, and might, by so much, have lessened the phthisis rate without necessarily diminishing the real prevalence of the disease throughout the country.

It seems certain, however, that neither of these intrusive faults can account for the remarkably steady fall in the rate. Phthisis is a disease so easily recognised in its later stages, that it has probably been reported, with a fair degree of accuracy, all through the period in question; and, sooner or later, most of the more chronic cases of phthisis must have found their way into the death-roll. There is thus no important bar to our hope of a speedy extinction of phthisis from our midst.

It is, however, necessary to note that the other tuberculous diseases, such as scrofula, mesenteric disease, and tuberculous meningitis, have not diminished within the same period in like proportion.

Dr. Tatham's last decennial supplement contains the following Table, from which it will be seen how slight a change has taken place, in the rates of these diseases, during the last thirty years :—

TABLE I.—*Annual Mortality per Million Living from Tuberculous Diseases, other than Phthisis*

Decennia			Rates per million
1861–70	...	...	765
1871–80	...	...	747
1881–90	...	..	696

I have noted these figures upon the Chart, and have also given the annual rates per 10,000 for the last twenty years, as given in the Registrar-General's Reports. The difference between the first and last decennial periods per million is only 69. The rates under the heading of 'scrofula' have, in fact, considerably increased. These facts would be somewhat difficult to account for, if we were to assume that the sources from which all tubercular diseases are derived are in all respects similar.

I have also received from Dr. Tatham the following Table showing the London Phthisis rate for the past ten years. It will be seen that, in that city, there was a diminution of more than 300 per million in ten years; a total gain in the ten years of about 1,350 lives.

TABLE II

Year	Population	Deaths from Phthisis	Rate per million	Percentage of Difference
1886	4,018,666	8,409	2,092	100
1887	4,058,565	7,832	1,930	92
1888 (leap year)	4,110,090	7,516	1,829	87
1889	4,139,555	7,774	1,878	90
1890	4,180,654	8,689	2,078	99
1891	4,221,522	8,319	1,971	94
1892 (leap year)	4,272,543	7,869	1,842	88
1893	4,300,580	8,043	1,870	89
1894	4,340,663	7,426	1,711	81
1895	4,381,119	7,779	1,776	84
1896 (53weeks)	4,494,645	7,778	1,731	82

Grouping together, then, all the different forms of tuberculosis, we may conclude that an enormous decrease in the disease has taken place; a decrease that means the saving of at least 75,000 lives every

year, in the present population of England and Wales; three quarters of a million of persons within the last decade.

Notwithstanding this great reduction in the mortality from the disease, however, it still remains far too prevalent at the present time. Nearly 60,000 persons die of tubercular disease every year in this country, and it may be calculated that at least 150,000 persons throughout the population are now suffering from this disease, in one form or another. There is thus ample reason for attempting to still further limit the spread of tuberculosis, and to study the best means for promoting its cure.

Statistics also afford proof of considerable mitigation in the character of the disease, and of the possibility of its cure in many cases. Dr. C. T. Williams points out ('Pulmonary Consumption,' p. 328) that the average duration of 1,000 cases, amongst well-to-do people, was four times greater than in Louis's or Laennec's cases; and he is confirmed in this view by Drs. James Pollock, Austin Flint, Wilson Fox, and others.

The evidence of more frequent cure of the disease is likewise very clear; and the proof of the possibility of spontaneous arrest of phthisis derived from the results of post-mortem examinations is overwhelming. It seems now to be a well-ascertained fact, from these researches, that from 20 to 30 per cent. of *all* persons dying in hospitals, between the ages of twenty-five and seventy-five, show signs of healed tubercular lesions.

These facts give us good ground for hope that the result of the research proposed by the Weber-Parkes Committee will be a still greater mitigation of the disease.

CHAPTER II

THE DISTRIBUTION OF TUBERCULOSIS IN NATIONS AND LOCAL AREAS

WITH reference to this subject the following facts, which are needed for ascertaining the etiology of tuberculosis, have been more or less completely established.

a. The almost universal presence of the disease and its independence of climate.[1]

From a careful study of the geographical distribution of phthisis, it will be found that the disease goes almost everywhere that man goes, and it is worst where human beings are most crowded together.

b. The Influence of Altitude.—It has been ascertained that the inhabitants of places over 3,000 feet above the level of the sea enjoy considerable immunity from phthisis. But this immunity is by no means entirely due to the rarity of the air in these places—a point that has been discussed by Dr. Emil Müller, in a treatise on the distribution of phthisis in Switzerland.

c. Persons who lead an almost entirely open air life are peculiarly free from the disease, whatever the climate.

d. Certain classes of operatives are especially liable to it, more particularly those who work in some mines, in badly ventilated workshops, or in atmospheres polluted by dusts, especially dusts of an irritating character.

e. In certain places, which at their first settlement were free from the disease, a high phthisis rate is often subsequently developed, and their populations become more and more subject to it as their density increases.

f. The following conditions exercise a favouring influence upon the spread of the disease: confined and impure atmospheres, damp subsoils, dark and ill-lighted dwellings.

[1] 'It is independent of climate, of latitude, and of altitude; but it is rigorously dependent upon the agglomeration of the population.' (Straus, *La Tuberculose et son Bacille*, p. 60.)

g. On the other hand, the opposite conditions often prevent, or at least control, the disease—namely, good ventilation, thorough drainage, abundance of sunlight.

These several propositions (*c* to *g*) are amply proved by the statistics of Drs. Headlam, Greenhow, Hirsch, Lombard; and by the Returns of the Registrar-General. Also by the numerous special instances recorded by Parkes, Hirsch, and others.

I shall, however, venture to record in this place an investigation of my own, on the influence of subsoil upon phthisis.

Inquiry II.—In this inquiry I have adopted a somewhat different method from those hitherto employed to show the antagonism of a pure well-drained subsoil to the spread of phthisis.

I had been struck by the freedom from the disease enjoyed by a section of the locality in which I lived, and it occurred to me that it would be interesting to ascertain how many cases originated in the different parts of the district.

A great portion of the region is elevated above the surrounding country, and is composed of deep, porous, sandy soil; but it is surrounded by boulder clay, the result of glacial drift. Most of the dwelling houses are built upon the thick bed of sand, which, in many places, is over 100 feet in thickness; but some cottages stand upon the clay. It was thus possible to make a comparison between those portions of the district. The climate on the sandy soil is more temperate than that on the clay, and the air and soil are drier and purer.

On the sandy downs, after the wettest weather, the paths speedily become dry, and the basement of a house is often as dry as its attic. It has the further advantage of being virgin soil. The sand is as pure and as free from organic matter as in the days when it was deposited by ice-floes, or was silted up from the river banks. No house is ever built upon freshly made ground, or on pits that have been filled up with refuse. The locality is well sewered, and has a plentiful supply of good water.

Moreover the inhabitants are, for the most part, well-to-do people. Out of a population of 2,559 by the last census, only about 500 are poor, and these live on the low-lying clay lands that surround the sandy dunes upon which the place is chiefly built. The remainder dwell in well-constructed, salubrious houses; they are well fed, and comfortable in their circumstances.

It will be seen that such a community lives under conditions peculiarly well fitted to preserve it from attacks of tubercular disease. I was, however, hardly prepared for the result of my inquiries. Owing to the kindness of the then Registrar-General, and of Dr. Farr, later

on also of Dr. Tatham, I was able to obtain from the Superintendent Registrar a complete return of all the deaths occurring in the district in the nine years 1875-84, and afterwards similar returns for the nine succeeding years.

Of the first group twenty-two deaths were from phthisis, but eleven of them took place on the low-lying clay lands before-mentioned, and nine of the remainder were found by inquiry to have contracted the disease before coming into the place. This leaves two to be accounted for; one of them was a gentleman who spent the greater part of his time in a neighbouring town, where he had frequently to attend crowded evening meetings. The other was a merchant's clerk, who went to town at 8 every morning and did not return until 7 P.M. No woman or child died of the complaint. The disease therefore did not originate in any of the stationary population resident, during the nine years, upon the sandy portions of the district.

The results obtained in the second group are strikingly like those just given. Again the total for the succeeding nine years was twenty-two deaths from phthisis, and of these nine were on the clay lands, thirteen on the higher ground, but seven of the latter were ascertained to have been imported. It must be remembered also that the population of these higher grounds was five times as numerous as that on the low ground.

These results are more definite than any I have elsewhere seen; but they could doubtless be paralleled by similar investigations in many other places.

Inquiry III.—h. The differences between the male and female phthisis rates in town and country districts afford, perhaps, the strongest proofs that can be given of the existence of causes much more powerful than mere climate in producing a tendency to consumption.

I append some figures taken from the 'Average Proportion of Deaths, from specified causes' (Blue Book). These show the male and female rates: (1) in places where the male rate exceeds that of the female; (2) in places where the female rate is much the highest.

It will be found that all the former are large towns, where the men are most attracted to indoor employments, whilst the latter are country places, where the females keep at home, and the men are chiefly occupied out of doors.

I have prepared the following Table, showing the differences between the male and female phthisis rate, in town and country places.

TABLE III.—ANNUAL AVERAGE PROPORTION OF DEATHS FROM PHTHISIS, BETWEEN THE AGES 15 AND 55, PER 100,000 PERSONS LIVING AT THOSE AGES, BETWEEN THE YEARS 1861 AND 1870.

Towns	Males	Females	Differences
Cambridge	570	395	−175
Whitechapel	560	430	−130
Bath	540	255	−285
Greenwich	525	375	−150
Brighton	520	345	−175
Southampton	500	385	−115
Birmingham	475	345	−130
Newcastle	470	395	− 75
Salisbury	440	305	−135
Sedburgh	365	615	+250
Congleton	360	615	+255
Bootle	225	555	+330
Leek	355	525	+170
Belper	275	455	+180
Buckingham	275	455	+180
Sevenoaks	290	455	+165
Alston	285	425	+140
Camelford	230	395	+165
Battle	180	365	+185
Pickering	160	315	+155
Billesdon	120	265	+145

A study of the preceding Table will show that in most of the country places the male rates are lower than the female rates. In the manufacturing towns the contrary is the case.

The few exceptions to these general rules are probably to be explained by the nature of the chief industries of the respective places, and by the degree to which male or female labour is attracted to them.

i. The distribution of phthisis amongst the different races of mankind also bears witness to the influence of surrounding circumstances upon susceptibility to the disease.

It is certain that races of men who, under one set of conditions, almost entirely escape from its ravages, are, under another, seriously exposed to its attacks.

We are told by both Hirsch and Lombard that there is almost complete immunity from the disease in Nubia and Upper Egypt, in Asia Minor, Syria, Arabia and Persia. Yet, in Asia Minor, it is often met with on the coast, or in the principal towns. The Bedouins on the coast of the Red Sea, who exchange their tents for stone-built houses, suffer from consumption. In Syria it is met

with at Aleppo, and in the Soudan at Khartoum. In Zanzibar it is said to be common among Arabian women of the higher class, owing to their greater seclusion. In Algeria, whilst the nomad Arabs are free, amongst the captives many die from the disease; and in Egypt it is noted that, whilst Syrians, Turks, Armenians, and Europeans seldom contract the complaint, Jews often become scrofulous, and also die frequently of consumption; negroes who are brought from the interior, to the coast, or to Europe, are very subject to tubercle. Icelanders, we are told ('Ruehle. Ziemsen.' vol. v. p. 491), frequently contract the disease on removal to Denmark; and Highlanders who inhabit well-built houses on the mainland of Scotland are subject to the same fate as the other inhabitants, whilst the ill-fed, ill-clothed fishermen of St. Kilda and the Hebrides, who are of the same race, hardly ever contract the disease.

All the above mentioned facts point to the conclusion that there is some material in unsanitary dwellings which tends to keep alive the virulence of the bacillus, and facilitates infection.

This conclusion is further emphasised by the last proposition to be noted respecting the distribution of the disease.

k. It frequently recurs in certain badly drained and otherwise unsanitary houses and in certain overcrowded, badly ventilated areas in large towns.

Inquiry IV.—I have myself made a special inquiry into this point. My attention was first called to it by the evidence referred to in the preceding paragraphs; but I had also been impressed by the incidence of tubercular disease upon certain houses in my own district, as well as by many of the cases of supposed direct infection, given by different medical men, in the 'Collective Investigation Record,' published by the British Medical Association.

These cases, with others that have been adduced by Dr. Hermann Weber, show at least the probability that tubercle may become endemic in certain houses.

I accordingly undertook an inquiry into the distribution of tubercular disease, especially phthisis, in certain parts of a large town.

The details of this investigation have already been published elsewhere.[1] It will be sufficient to say now, that they show that the portions of this town most affected by tubercular disease were the close courts and alleys, the shut-in or blocked-up lanes, and, above all, the houses built back-to-back, with no through ventilation.

[1] 'Some Evidence respecting Tubercular Infective Areas' (*Trans. of Epidem. Society*, vol. vi. N.S.)

Cases were especially noted in which, during the period of five or six years included in the inquiry, double or treble occurrences of the disease had taken place in the same houses, and these cases were very numerous.

In one district, with a population of about 5,600 persons, there were 150 deaths from tubercular diseases in the course of five years; thirty each year; 5·3 per 1,000.

About half the deaths from these diseases took place in narrow courts, opening by passages from the streets, or in short, blocked-up lanes.

In twenty-one of the houses, there were two or more deaths in each house; forty-four deaths in all; and thirty of these occurred in the narrow streets, culs-de-sac, or small courts.

In another district, there were nearly 9 per 1,000 deaths from tubercular disease, and out of 47 such deaths 29 took place in two narrow blocked-up streets; all in back-to-back houses.

In two other districts, similar results were obtained.

These results have since been confirmed by other observers, most recently by Dr. Chalmers, Medical Officer of Health for Glasgow.

Summary.—It is scarcely necessary to point the moral to be drawn from the distribution of tuberculosis as portrayed in the preceding paragraphs.

They surely show that, in the crowded populations and in the wretched homes where the disease prevails there must exist some material which favours the continuous existence of the specific microbe, and which may possibly even increase its virulence.

The researches which have shortly to be recorded, in Chapter III. (p. 15), may perhaps demonstrate what this material is; but, in any case, it is abundantly evident that, for the prevention of the disease, one measure in particular will certainly have to be carried out, and that is the abolition of overcrowding, and the destruction of all forms of organic pollution of the air.

CHAPTER III

THE NATURAL HISTORY OF THE BACILLUS OF TUBERCLE

It is necessary to give a brief résumé of what is known respecting the natural history of the bacillus of tubercle, as this organism is now almost universally recognised to be the essential cause of tuberculosis.

The most important researches on the subject are those made by Professor Koch, the discoverer of the microbe. So far as they extend, his conclusions remain undisturbed by subsequent inquiries, and may surely now be regarded as established facts.

The following observations are mainly derived from Koch's original article in the 'Berliner Klin. Woch.,' April 10, 1882; and from the translation of his works in the Sydenham Society's volume.

1. The fact that the bacillus of tubercle, as well as that of leprosy (and perhaps the Smegma bacillus), contain a special substance capable of fixing and retaining aniline dyes.

2. The presence of the bacillus in all the various forms of the disease, and its absence in all other diseases.

3. The production of pure cultivations of the organism.

4. The media upon which it may be freely cultivated, such as blood serum, agar peptone, potato, &c.

5. The transmission of the disease to animals, by inoculations of these pure cultivations.

* 6. The discharge of the bacillus in enormous quantities in the sputum from tuberculous lungs.

* 7. The presence of the organism, in some cases, in the flesh or the milk of tuberculous animals.

* 8. The periods of incubation of the organism when cultivated upon different media, varying from one to three weeks or more.

* 9. The temperatures at which it can be cultivated, the most favourable being that of the mammalian body.

* 10. The tenacity of life of the organism under certain con-

ditions, and notably its resistance to the action of the gastric juice, to drying, &c.

* 11. The speedy destruction of the virulence of pure cultivations by sunlight and air. (See Dr. Koch's address to the 10th International Medical Congress, Berlin, 1890.)

* 12. The antagonism to it of the living elements, and its short life in the body under certain conditions.

To these observations have now been added others of more or less importance, by Professor Koch and others, notably :—

13. Certain variations in the cultivation of the microbe, such as its facilitation by the addition of glycerine, by the addition of solidified egg albumin, by the use of milk with 5 per cent. of glycerine.

* 14. The observation of Nocard and Roux that sub-cultures from glycerine agar-agar, or from glycerine broth, will give cultures in ordinary broth without glycerine. (Other variations noticed by myself will be described presently.)

* 15. The bacillus has been made to grow on potato by Sir H. Beevor, Kanthack, and others, at ordinary temperatures ; and I have myself grown it upon other media, at a temperature of from 20° to 22° Cent.

16. The differences between the bacillus of human and avian tuberculosis have been fully described by Straus, Flügge, Klein, and others.

17. The same observers have noted variations in its form, in its virulence, and in the susceptibility to it of different animals.

18. A mycelial (branched and clubbed) form has been noticed by several observers, notably by Klein ('Report of Medical Officer of Local Government Board,' 1889–90). These forms, described also by Metschnikoff, Czaplawski, Fischel, Lubinsky, and others, are supposed by some to show that the organism is a mould (Hyphomycetes), and by others again that it is allied to the Actinomyces (Jones, Sternberg, p. 413). I have myself observed these forms in some cultivations hereafter described.

19. At the present time, the differential classification of the bacillus is said by Crookshank to be determined by the following characters : I. Aerobes, or facultative anaerobes. (*a*) No growth in gelatine. (*b*) Spore formation present, non-motile, found in tubercular material only.

20. Other microbes, such as the M. Tetragonus, Streptococcus, &c., have been noted as constant associates of the bacillus (Straus).

* 21. The resistance of the bacillus to certain disinfectants

and to some natural agencies such as desiccation, low temperatures, putrefaction, &c. (Fischer and Schill, Galtier, and others).

22. The Röntgen rays are said by MM. Lortet and Genoud to have some influence in mitigating the virulence of tubercle; but, as yet, this action cannot be accepted as proved.

* 23. The production of toxines by the tubercle bacillus, such as tuberculin, and their physiological and pathological properties (Koch).

* 24. The reaction and rise of temperature produced by the injection of tuberculin in tuberculous animals, not in others (Koch).

25. It is probable that an attenuation of virulence of the bacillus may take place, by keeping it at a temperature of 42°, or by prolonged drying; and it is most likely that this attenuation of virulence is due to the diminished production of some toxic product.

There are also a few researches more especially relating to the pathology, histology, and etiology of tubercle. They are:—

26. Researches respecting the nature of the actions set up in the animal frame by the bacillus; the inflammatory nature of tubercle, and the subsequent changes in the tissues due to its presence.

27. Researches as to the formation of 'giant-cells' in tuberculosis and in other diseases. (In these cells the relation of the tubercle bacillus to the nuclei have been especially studied.)

28. The relations of other phagocytes to the bacillus. 'It is not unusual to find in the giant-cells some bacilli which evidently are undergoing degenerative changes . . . . while elsewhere they are apparently proliferating, despite their intracellular position.' (Adami. 'Syst. of Med.,' vol. i. p. 83.)

* 29. Some evidence respecting the 'dosage' of the specific virus necessary for the infection of animals and human beings, chiefly contributed by Bollinger, Hirschberger, Gebhardt, and Wyssokowitsch.

* 30. The demonstration of the presence of virulent tuberculous dust in rooms previously occupied by consumptives and in ill-ventilated convent cells, and its absence in other places (Cornet).

31. The relations between tuberculosis and leprosy and other diseases (Thin, Ransome, &c.), and observations as to the formation of non-specific nodules resembling tubercle by other microbes (Straus), and by different forms of dust (Wilson Fox, Arlidge, and others).

32. The influence of drugs, foods, and other conditions in rendering animals, otherwise immune, susceptible to tuberculosis (Kanthack, quoting Fermi and Salsano, in 'System of Medicine,' vol. i.)

Certain points concerning modes of infection and the conditions of infectiveness by the bacillus will be considered subsequently.

Most of the subjects just enumerated have some bearing upon the questions of the best modes of prophylaxis against tubercle, or upon its treatment; notably those marked thus * (Nos. 6, 7, 8, 9, 10, 11, 12, 14, 15, 21, 23, 24, 29, 30).

Many of them may be allowed to pass without further elucidation, but some of them are still *sub judice*, and need closer consideration.

Numbers 4, 8, 9, 11, 14, 15, 18, and 21 have been made the subjects of special investigation by myself, and will be more fully noticed in the following inquiries.

RESEARCH ON CERTAIN CONDITIONS OF GROWTH OF THE BACILLUS OF TUBERCLE

Numerous experiments have been made by different observers upon the conditions essential to the cultivation of the bacillus. Amongst the most recent and complete are those by Beck and Proskauer ('Zeitsch. für Hygien und Infectionskrank,' Band 18, Erst. Heft, p. 128).

All these observations have, however, been of the nature of purely 'laboratory' researches, consisting chiefly in the trial of various compounds, organic and inorganic, selected for various reasons.

Doubtless these experiments are of value, especially those contained in the paper above mentioned, which show that, provided there is some nitrogenous matter present, and in most cases a small proportion of glycerine, the majority of the compounds tried suffice to nourish and promote the growth of the bacillus of tubercle.

But, so far as I know, no attempt has been made, in the laboratory or elsewhere, to imitate the actual conditions that prevail in houses or places of public assembly, where it is notorious that phthisis has been known to spread infectively, nor yet to contrast these conditions with those that prevail in places where such infection does not take place, or where it is at least a very rare occurrence.

During the last few years I have at different times made attempts to solve the problem above indicated. The history of the disease, as we shall see presently, makes it easy to discover the direction in which to search for a solution. It is agreed by all authorities, and the statistics given in the preceding sections go to prove, that phthisis chiefly prevails in densely crowded populations; especially where individuals are closely packed together in low-lying, badly drained localities where the rooms they live in are charged with all kinds of organic impurity, and especially with emanations from the lungs or bodies, or with 'ground-air' vapours, from soil reeking with putrefying organic material.

It was with the view of testing the fitness of such places for the cultivation of the bacillus, or at least for the preservation of its virulence, that this research was commenced; and, in addition, it was determined to attempt the discrimination between the several circumstances, which might seem to have a favouring influence in keeping alive or even in increasing the virulence of the specific microbe. Such circumstances are, for instance, polluted atmospheres, absence of sunlight, impure subsoils, &c.

Throughout the inquiry I have had the advantage of most able assistance from bacteriologists who possessed the necessary 'licence' for some of the experiments which had to be performed.

Inquiry V.—In the first series of trials undertaken, with the help of Professor Dreschfeld, of the Owens College, tuberculous sputum, ascertained to be rich in bacilli, and virulent to rabbits, was exposed (*a*) in a locality where the soil was dry and sandy, and where very few cases of phthisis were known to have originated. It was placed in full daylight or sunlight, and exposed to abundant streams of fresh country air.

(*b*) A portion of the same sputum was exposed, under similar conditions, in the same place, with the single exception that it was placed in a darkened chamber.

(*c*) A third portion was taken to a small four-roomed tenement, in a large town, on a clay soil, without cellarage, and badly ventilated, where several deaths from phthisis had taken place. It was placed on a window-ledge, with as much light and air as could there be obtained.

(*d*) A portion was placed in the same cottage, in a dark corner of a sleeping-room.

(*e*) Another portion was exposed to used air coming from a ward in a Consumption Hospital, in darkness.

(*f*) Finally, a portion was placed, in darkness, but exposed to free currents of fresh air, under a ward in the same hospital.

All these specimens were exposed in watch-glasses, some of which, where there was a possibility of infection, were surrounded by a kind of cage of cotton-wool.

The duration of the exposure to these conditions varied from eight to ten weeks. The results of their subsequent inoculation into rabbits are given in the 'Proceedings of the Royal Society,' Vol. XLIX. p. 66. They may here be briefly summarised.

(*a*) None of the four specimens exposed to fresh air and light, on a dry, sandy soil, conveyed the disease.

(*b*) Two portions, exposed under similar conditions, in darkness, were also innocuous.

(*c*) Of the two specimens exposed in the poor cottage, in the light, one produced tubercle, the other did not.

(*d*) Of other two specimens exposed in the same cottage, in partial darkness, one caused tubercle, the other did not.

(*e*) and (*f*) Of the two specimens exposed at the Consumption Hospital, both in darkness, but one in pure, the other in impure air, both gave the disease to rabbits.

These experiments were too few in number to justify positive conclusions; but, so far as they extend, they go to prove that fresh air and light and a dry and sandy soil have a distinct influence in arresting the virulence of the tubercle bacillus; that darkness somewhat interferes with the disinfectant action of the other conditions; but that the mere exposure to such light as could be obtained, in otherwise bad sanitary surroundings, does not destroy the virus.

There were also some indications that the presence of a cotton-wool envelope may interfere somewhat with the action, for good or evil, of both good and bad air respectively.

Further observations were also made with sputum which was kindly exposed for me, by the late Professor Tyndall, at Bel-Alp, Switzerland, in light and in darkness, each kind for ten days and fourteen days respectively, and compared with the same sputum exposed in the cottage in Manchester. The results from all these specimens were entirely negative, probably owing to something being wrong with the sputum, which had not been previously tested by inoculation.

Inquiry VI.—More recently, in 1894, another professor[1] joined

[1] Professor Delépine.

me in the work; and we made an attempt to determine how short a period of exposure to light and air would suffice to destroy the virulent action of the microbe.

The experiments were made both with pure cultivations and with dried sputum, the latter in some cases scraped and reduced to dust. Guinea-pigs were used for the inoculations.

The details of the preliminary experiments and their results are given in a Report made to the British Medical Association, and published in the 'British Medical Journal,' February 16, 1895.

In the first place it was necessary to test the virulence of the cultivations about to be used, and to compare these tests with the results of inoculations made with non-tuberculous material.

These experiments are detailed in Table II. of that Report. Others relating to the avian bacillus are given in Table III. In all these inoculations there is absolutely no instance of failure; and the amount of tuberculosis produced was, in all cases but one, proportional to the number of days the animals were kept alive after inoculation.

On the other hand, no trace of tubercle followed any of the inoculations with non-tuberculous material.

The effect of 'drying' was next tried upon the virulence of both pure cultivations and of tuberculous sputum. This simply means that the specimens were kept in the dark, in closed capsules, so that but little air had access to them. It was thus found that moderate desiccation slightly retards the first manifestations of tuberculosis; prolonged drying ultimately kills the bacillus. After 130 days' drying, the virulence, in three experiments, was altogether destroyed.

These results are detailed in Table IV. of the Report.

In Table V. similar results are shown from tuberculous sputum; but, in this case, after 54 days' keeping sputum was found to be still very virulent.

For our immediate purpose we must now pass on to the results contained in the following Tables, XII., XIII., and XIV. (pp. 20, 21).

These tables are intended to show the influence of free ventilation and of sunshine, or of both combined, both upon pure cultivations and upon tuberculous sputum.

So far as the experiments go (detailed in Table XII., 'Simple Ventilation in the Dark'), they show that ventilation diminishes, but does not necessarily destroy, virulence. In one instance (No. 170) in which the sputum was not broken up, after three days' exposure to a good current of air, it gave tubercle to a guinea-pig; and in

another similar case (No. 8), in which the ventilation was moderate for twenty-eight days, it gave slight tuberculosis to a rabbit.

On the other hand, all the experiments detailed in Tables XIII. and XIV., in one series of trials, showed that very short exposures to both sunlight and air sufficed to deprive the organism of all virulence. In one case (Table XIII., No. 190) a specimen, exposed to both light and air for two days only, with but little radiant sunshine, was found to have entirely lost its power for evil. Another specimen exposed for three days, with only one hour of sunshine, gave a similar result (Table XIII., No. 156).

These tables are given on the next pages.

In the 'Proceedings of the Royal Society' (vol. lvi.) will be found a further account of a set of experiments, also conducted by Professor Delépine and myself, from which it appears (Table II. No. 160) that sputum kept for three days, in a dark closet, but in a current of air (about 1,000 cubic feet per hour), showed some retardation of virulence, requiring thirty-two days to produce marked tuberculosis in a guinea-pig. Two other specimens, sputum (*b*) gave no result, after eight days' exposure to currents of air, in darkness; though another specimen, after nineteen days' keeping in a close cupboard, gave marked tuberculosis in fifty days.

It may be noted that, in all the experiments on light and air, in this Inquiry, the times of exposure ascertained to be sufficient for disinfecting the tubercle bacillus were less than would suffice for the pulverisation of sputum, under ordinary circumstances; yet specimens of the same material gave tubercle to guinea-pigs, after it had been kept in the dark with very little air for thirty-five days.

It must also be remembered that the tests of its virulence were much more delicate than would be found under usual conditions. The animals employed as tests are the most susceptible to the disease that can be found; and they took the virus through inoculation, and not merely by breathing. The usual safeguards against infection by the latter channel, therefore, were absent; and human beings may be expected to be much less vulnerable than guinea-pigs and rabbits.

The conclusions to be drawn from the above experiments are:—

(1) That finely divided tuberculous matter, such as pure cultivations of the bacillus, or tuberculous matter derived from sputum, in daylight and in free currents of air, is rapidly deprived of virulence

TABLE XII.—EFFECT OF VENTILATION ON THE VIRULENCE OF TUBERCULOUS PAPERS WERE KEPT IN THE DARK, AND IN CLOSED CAP-

No. of Experiment	Date	Animal used	Seat of inoculation	Quantity of sputum	No. of days sputum kept drying
170	March 1894	Guinea-pig	Subcutaneous tissue of leg	$\frac{1}{8}$ c. cm.	17
160	Feb. 1894	,,	,,	,,	9
203	June 1894	,,	,,	$\frac{1}{10}$ c. cm.	25
8	June 1892	Rabbit	Peritoneum	1 c. cm.	45

In none of these experiments

TABLE XIII.—EFFECT OF SUNLIGHT ON THE VIRULENCE OF TUBERCULOUS PAPERS, WHEN NOT EXPOSED TO SUNLIGHT AND TO AIR,

No. of Experiment	Date	Animal used	Seat of inoculation	Quantity of sputum	No. of days kept drying	Ventilation	
						No. of days	Amount
186	March 1894	Guinea-pig	Subcutaneous tissue (leg)	$\frac{1}{8}$ c. cm.	32	3	Good
187	,,	,,	,,	,,	,,	,,	,,
188	,,	,,	,,	,,	,,	7	,,
189	,,	,,	,,	,,	35	,,	,,
190	,,	,,	,,	,,	,,	2	Slight
202	June 1894	,,	,,	1 c. cm.	25	1	Moderate
156	Feb. 1894	,,	,,	$\frac{1}{8}$ c. cm.	4	3	,,
11	June 1892	,,	,,	$\frac{1}{4}$ c. cm.	45	28	,,
7	,,	Rabbit	Peritoneum	1 c. cm.	,,	,,	,,

TABLE XIV.—EFFECT OF SUNLIGHT ON THE VIRULENCE OF PURE CULTIVATIONS THE PAPERS, AFTER BEING INFECTED, WERE TREATED EXACTLY

No. of Experiment	Date	Animal used	Seat of inoculation	Quantity of bacilli	No. of days kept dr, ing	Ventilation	
						No. of days	Amount
85	July 1893	Guinea-pig	Subcutaneous tissue (leg)	$\frac{1}{4}$ c. mm.	9	4	Good
98	,,	,,	,,	,,	13	—	Bad
97	,,	,,	,,	,,	,,	—	,,
110	August 1893	,,	,,	,,	24	24	Slight

SPUTUM. SPECIMENS OF TWO DIFFERENT SPUTA WERE USED; THE INFECTED SULES, WHEN NOT SUBJECTED TO A CURRENT OF AIR

Ventilation		Results		Remarks
No. of days	Amount	No. of days animals kept after inoculation	Degree of tuberculosis obtained	
3	Good	24	II	Sputum not broken up after being dried
8	Moderate	32	III	Sputum broken up
2	Good	37	III	Sputum not broken up
28	Moderate	86	Slight	—

did the temperature rise above 30° C.

SPUTUM. SPECIMENS OF FOUR DIFFERENT SPUTA WERE USED; THE INFECTED WERE KEPT IN CLOSED CAPSULES IN THE DARK

Maximum temperature (Centigrade)	Sunlight		Results		Remarks
	Diffuse in days	Radiant hours	No. of days animals kept after inoculation	Degree of tuberculosis	
About 30°	3	3 bright afternoons	4 [1]	0	All these sputa were known to be infectious in control experiments
„	?	?	7 [1]	0	
31·0°	7	15 hours	7 [1]	0	
„	„	„	22	0	
15·5°	2	Short time	„	0	
30·0°	1	9 hours	37	0	
10·0°	3	1 hour	46	0	
?	28	?	80	0	
?	„	?	86	0	

[1] Time insufficient.

OF BACILLUS TUBERCULOSIS HOMINIS. ONE CULTURE ONLY WAS USED, AND AS IN EXPERIMENTS RECORDED IN TABLE XIII

Maximum temperature (Centigrade)	Sunlight		Results	
	Diffuse in days	Radiant hours	No. of animals kept after inoculation	Degree of tuberculosis
40°	4	13	43	0
36°	2	6¼	78	0
40°	6	18½	150	0
?	9	?	140	0

(2) That even in the dark, although the action is retarded, fresh air has some disinfecting influence; and

(3) That in the absence of currents of air the bacillus retains its power for long periods of time.

These observations afford an explanation of the immunity of certain places, and the danger of infection in others. They show that where tuberculous sputum is exposed to sufficient light and air to deprive it of virulence, before it can be dried up and powdered into dust, no danger of infection need be dreaded. It would appear further from this research, and the others before instanced, that it is only when there is sufficient organic material in the air, derived from impure ground air, or from the reek of human bodies, that the tubercle bacillus can retain its existence, and its virulent power. Long-lived though it may be under these latter conditions, it is rapidly disinfected by the natural agencies of fresh air and sunlight; so rapidly indeed, that, when these agents are present, even in comparatively moderate degree, the tuberculous material cannot reach its dangerous state of dust before it is deprived of all power of doing harm.

Inquiry VII.—But, in addition to the above-mentioned researches, it seemed desirable that an attempt should then be made to ascertain what part was played by each of the several forms of organic impurity, which are present in dwellings. To this end, it was determined to collect the aqueous vapours arising from the ground, or from human bodies, and to submit these products to the test of trying whether they would serve as cultivating media for the bacillus of tubercle.

Many years ago, in a research the particulars of which are given in the Appendix to my book on 'Stethometry' (Macmillan & Co.), I examined the condensed aqueous vapour of the breath, in health and disease, and ascertained the quantity of organic matter that it contained. The breath of fifteen healthy persons, and of twenty-seven diseased persons, was examined chemically by Wanklyn's method of water-analysis, and also microscopically. The fact of chief importance obtained was, that every specimen contained a small but appreciable quantity of both free and organic ammonia. The quantity from the cases of disease varied considerably, but that from healthy persons was remarkably constant, varying from 0·325 milligrammes to 0·45 per 100 minims of the fluid collected, the average being 0·4. Hence, by calculation, we obtain the rough

estimate, that about 3 grs. of organic matter are given off from a man's lungs in the course of twenty-four hours.

This doubtless is a very small amount; but it is sufficient to render the aqueous vapour so thrown off more impure than most sewage water, and it is ample in quantity to foster the growth of organic germs.

It was this experience that induced me to try the cultivation of the bacillus of tubercle upon these and similar fluids, such as are likely to be met with in dwelling-houses.

By means of a simple freezing mixture of ice and salt it was easy to condense the aqueous vapour, both that of the breath and that coming from ground air; and, in order to make the inquiry more complete, the vapour of the breath, both from healthy and from diseased persons, was collected in a flask surrounded by this mixture.

In other words, both healthy persons and those affected by phthisis were prevailed upon to breathe into the flask, until a sufficient quantity of aqueous fluid had been obtained.

With another apparatus, consisting of a framework supporting beakers containing freezing mixture, collections of aqueous fluid were obtained from 'ground air' coming from a wine-cellar, in a gravelly subsoil, and from cellars under several low-lying insanitary cottages in Southampton. Some of the moisture from a weaving-shed in Blackburn was also thus collected, and used as a cultivating medium. The composition of these latter fluids is given below.

TABLE I.—COMPOSITION OF CONDENSED AQUEOUS VAPOURS, FROM FOLLOWING SOURCES

Sources of fluids	Parts by weight of ammonias per 100,000		Grains per gallon of ammonias	
	Free and saline	Albuminoid	Free and saline	Albuminoid
1. Healthy breath	1·622	3·568	1·135	2·497
2. Phthisical breath	·973	2·598	·681	1·816
3. Gravel subsoil cellar air	·649	1·622	·454	1·135
4. Southampton cellar air	2·141	3·893	1·498	2·724
5. Pure sandy soil	·020	·030	—	—
6. Blackburn weaving-sheds (average) (humidified)	·319	·082	·223	·057
7. Thames sewage at south outfall (Keats)	2·309	3·893	1·498	2·724

These several liquids were carefully sterilised, and were then used in various ways for the cultivation of the bacillus of tubercle.[1]

Two well-grown specimens of pure cultivations were obtained, both through Dr. Childs of University College, one (*a*) from the Institute of Preventive Medicine, the other (*b*) from a private source, but, since the latter specimen could not be guaranteed as human bacillus, it was labelled as of doubtful origin ; and the two sets of cultivations made from these different sources were kept separate.

In order to test the activity of these cultures, they were each, in the first instance, sown (*a*) upon sterilised blood-serum, and (*b*) upon 'agar-peptone,' because these media were known to be the best for cultivating purposes, and the results could then with advantage be compared with those from the other materials used.

Both specimens were found to be capable of active growth, though the cultivation of (*A*) was somewhat more tardy than that of (*B*).

TABLE II

No.	Media	—	Date of inoculation	Periods of incubation (at 35° Cent.)			
				Two weeks	Four weeks	Eight weeks	Twelve weeks and upwards
10	Blood-serum . .	A	April 3	—	x	xx	xxx
11	Agar-peptone . .	A	„	—	x	xx	xxx
67	Blood-serum . .	B	„	xx	xxx	xxx	—
68	Glycerine agar. .	B	April 13	x	xx	xxx	xxx
19	Agar-peptone . .	B	April 3	xx	xxx	xxx	—

The crosses denote degrees of growth. One x means the first appearance of a colony. Two (xx), two or more colonies, evidently growing. Three (xxx), growth extending over the medium.

It was then thought well, in the first instance, to attempt to cultivate the bacillus upon media on which it grows with difficulty, without the presence of added peptones. In other words, to find out whether the presence of the condensed organic fluids from the sources that have been mentioned would replace the peptones.

Accordingly, simple agar jelly with 6 per cent. of glycerine was made with each of the fluids mentioned, after a careful sterilisation. Tubes were charged with these several compounds, inoculated with looped platinum wire, lightly charged ; stoppered with sterilised

[1] The various manipulations in this inquiry were carried out by Mr. Tanner, in his Bacteriological Laboratory, at Bournemouth, and to his care and skill much of the success obtained is due.

wool, capped, and placed in an incubator, kept at a temperature of 35° Cent.

At the same time slips of potato, after thorough sterilisation, were soaked in the fluids and inoculated, and similarly disposed of.

As a control experiment the agar jelly was made with simple distilled water and glycerine, charged and disposed of in the same way.

The results of these several experiments are shown in the two following tables.

It will be observed that out of the eighteen specimens only two (both of them from the impure cellars) failed to produce growth to some extent. Those that did best were the fluids from the cellar in pure porous soil, and those condensed from the breath of phthisical patients. But all kinds of organic fluid showed growth on either agar jelly or potato.

TABLE III

Agar with condensed fluids and glycerine		Date of inoculation	Periods of incubation and growth (in incubator at 35° Cent.)			
No. of experiment	Media		Two weeks	Four weeks	Eight weeks	Twelve weeks and upwards
		Culture (A)				
17	Agar with 5 per cent. of glycerine	April 13	—	x	xx	xx
	Condensed vapour from the following sources:					
4	1. Cellar in pure porous soil	April 3	x	xx	xxx	xxx
5	2. Cellar in pure porous soil	„	x	xx	xxx	xxxx
1	3. Cellar in pure porous soil	April 10	—	—	x	Faint
2	4. Cellar in pure porous soil	„	—	—	x?	„
9	5. Impure cellar on clay	„	—	—	—	Blank
10	6. „ „ „	„	—	—	—	„
13	7. Healthy breath. .	„	—	x	x	xx
14	8. „ „ . .	„	—	x	x	xx
6	9. Phthisical breath .	April 3	x	xx	xxx	xxx Blackened
7	10. „ „ .	„	x	xx	xxx	xxx

TABLE IV

No. of experiment	Media	Date of inoculation	Periods of incubation and growth (in incubator at 35° Cent.)			
			Two weeks	Four weeks	Eight weeks	Twelve weeks and upwards
	Sterilised potato and the vapours as above	*Culture (A)*				
3	1. From cellar in pure porous soil	April 3	x	xxx	xxxx	xxxx
21	2. From cellar in pure porous soil	„	x	xx	xx	Feeble
11	3. Impure cellar in clay.	April 10	—	—	xx	xxx
12	4. „ „ .	„	—	—	xx	xxx
15	5. Healthy breath . .	„	—	x	xx	xx
16	6. „ „ . .	„	—	xx	xx	xxx
8	7. Phthisical breath .	April 3	—	x	xx	xxx

There is thus some evidence that the organic fluids facilitated cultivation to some extent. Experienced bacteriologists, who have attempted to use simple potato or glycerine agar as the cultivating medium, have assured me that failure is much more common than success, and that the growth, when it does take place, is usually very slow. With the organic fluids there were only two failures, and growth was fairly rapid.

In the next series of trials it was decided to use as the material bases some non-nitrogenous substance, and attempts were made to employ pieces of wood, cork, cotton-wool, and fine spun glass, the last-named at the suggestion of a distinguished bacteriologist. None of these bases were found to be satisfactory ; and at length it was determined to use a particularly pure 'filter-paper,' manufactured by Messrs. Schleicher & Schull, from which even the salts had been extracted by washing with hydrochloric and hydrofluoric acids.[1] This paper, after being sterilised, was folded in a convenient form, inserted in the test-tubes, and charged with the several organic fluids, to which, as before, 6 per cent. of pure glycerine had been added. It was then inoculated, stoppered as before, and in the first trials these tubes were placed in the incubator at the usual temperature of 35° Cent.

The results are shown in Table V.

[1] Each of these filter-papers, analysed by the Kjeldahl process by Sir H. Roscoe's assistant, was found to contain only 0·1 milligramme of nitrogen.

TABLE V

No. of experiment	Media	Date of inoculation	Periods of cultivation (in incubator at 35° Cent.)				Remarks
			Two weeks	Four weeks	Eight weeks	Twelve weeks	
	Chemically pure filter-paper and condensed fluids, with 6 per cent. glycerine	*Culture (A)*					
49	1. From pure cellar air	May 23	?	x	xx	xx	
50	2. „ „	„	?	x	x	xx	
43	3. From impure cellar air	„	x	x	xx	xx	
44	4. From impure cellar air	„	x	xx	xx	xx	
58	5. Weaver's shed	June 5	—	x	x	x	
59	6. „ „	„	—	x	x	xx	
62	7. Healthy breath	„	—	x	xx	xx	
63	8. „ „	„	—	x	x	xx	
46	9. Phthisical breath	May 23	x	x	xx	xxx	
47	10. „ „	„	—	—	—	—	
55	11. Distilled water	„	—	—	—	—	Medium found to contain free ammonia
56	12. „ „	„	—	—	—	—	
		Culture (B)					
51	1. Pure cellar air	May 23	—	x	xx	xx	
45	2. Impure cellar air	„	—	—	—	—	
60	3. Weaver's shed	June 5	—	x	x	xx	
61	4. Healthy Breath	„	—	x	xx	xxx	
48	5. Phthisical breath	May 23	—	—	—	—	
54	6. Distilled water	„	—	—	—	—	

It will be seen that some degree of success was attained in twelve out of fifteen specimens of the organic fluids. Both the failures were with phthisical breath. No growth with distilled water.

The degree of growth was also much the same as in the previous series, though perhaps slightly less vigorous.

It was now determined to try to do without the help of the glycerine, which, as is well known, so greatly assists the ordinary cultivations of the bacillus. Accordingly four tubes with simple filter-paper as the supporting medium, and condensed fluids, from the breath of a healthy person, and from that of a phthisical patient, as

the nutrient fluids, were inoculated, and no glycerine was added. In these tubes the same cultivation was used as in the previous experiments.

Shortly afterwards, two similar tubes with fluid from healthy breath alone, but with 5 per cent. of glycerine, were sown with the same cultivation, and were left at the ordinary temperature of the laboratory, about 21° Cent. (See Table VI.)

TABLE VI

No. of experiment	Media	Date of inoculation	Periods of cultivation				
			Two weeks	Four weeks	Eight weeks	Twelve weeks	Sixteen weeks
	Pure filter-paper, with condensed fluids alone (no glycerine)						
	In incubator at 35° C.	*Culture (A)*					
72	1. Healthy breath .	July 21	—	x	xx	xx	
73	2. Ditto. .	,,	—	x	x	x	
70	3. Phthisical breath .	,,	—	x	x	x	
71	4. Ditto. .	,,	x	xx	xxx	xxx	
	Same with 5 per cent. glycerine at temperature of laboratory (or about 21° Cent.)						
74	1. Healthy breath .	,,	—	—	—	—	
75	2. Ditto. .	,,	x	xx	xx	xx	
	Same medium without glycerine	*Sub-culture*	One month	Two months	Three months	Four months	
77	1. Phthisical breath .	Sept. 17	—	—	—	x	x
76	2. Ditto. (35° C.) .	,,	—	—	—	—	—
78	3. Ditto. (ord. tem.)	,,	—	—	—	—	—
79	4. Ditto. (ord. tem.)	,,	—	—	—	—	—
80	5. Healthy breath .	,,	—	—	—	—	—
81	6. Ditto. (35° C.) .	,,	—	—	—	—	—
82	7. Ditto. (ord. tem.)	,,	—	—	—	—	—
83	8. Ditto. Ditto.	,,	—	—	—	—	—
84	9. Blackburn shed (35° C.) . .	Sept. 24	—	—	—	—	—
85	10. Ditto.	,,	—	—	—	—	—
86	11. Ditto. (ord. tem.)	,,	—	—	—	—	—
87	12. Ditto.	,,	—	—	—	—	—

All of the former group took on active growth within four weeks, and one of the latter. In other words, it was proved that pure filter-paper moistened with these condensed fluids alone would

suffice to nourish and promote the growth of the bacillus; and, further, that this growth would take place at ordinary temperatures. It may hence be concluded that when this organic fluid is present in ordinary dwellings the bacillus may grow at the temperature of living-rooms as well as at the temperature of 35° Cent.

In September 1896 another attempt to test this point was made by inoculating a dozen more tubes in which the various condensed fluids were employed as nutrients. Some of them were placed in the incubator, the others being placed outside.

In this series, however, a sub-culture on agar-peptone taken from the old Preventive Institute tube was used as the seed, and it was soon evident that this sub-culture had greatly declined in vigour. For three months no perceptible growth took place on any of the specimens; and then only on phthisical breath to a very slight extent.

Although they must be counted for the most part as failures, the results of the experiments are given in the continuation of Table VI.

Yet another attempt was made with this last-used cultivation, and a fresh series of eight tubes was commenced on October 31, but these also proved failures.

In February 1897, through the kindness of some friends, a fresh tube of apparently vigorous cultivation of the tubercle bacillus, guaranteed to be of human origin, was obtained.

By way of control, this culture was sown upon blood-serum and upon agar-peptone, and incubated at 37° Cent. A copious growth commenced on the blood-serum, within ten days' time. (See Table IX.)

Two sets of tubes were prepared of condensed vapour from breath, and of that from ground air in pure sandy soil. No glycerine, but a little gelatine was added, and for the solid medium in some instances the pure filter-paper was employed, in others an ordinary lining-paper containing a little size but carefully sterilised.

Some of these tubes were placed in the incubator at a temperature of 37° Cent., as this higher temperature might be more favourable to growth. Others were left in the dark at the ordinary temperature of the laboratory. The results are shown in Tables VII. and VIII.

It will be seen that in many of the tubes a free growth was observed as early as the end of the first fortnight.

In thirty-six instances out of the total number of thirty-seven

TABLE VII

No. of experiment	Media with fresh culture	Temperature	Date of inoculation	Periods of cultivation				Remarks
				Two weeks	Four weeks	Two months	Three months	
	Pure filter-paper, with following vapours and ½ per cent. gelatine	Cent.						
96	Pure ground air	37°	Feb. 10	x	xx	xxx	xxx	
97	,, ,, ...	,,	,,	x	x	xx	xx	
100	Healthy breath	,,	,,	x	x	x	xx	
101	,, ,, ...	,,	,,	—	—	—	—	
	Same, without gelatine							
104	Pure ground air	22°	,,	x	x	xx	xx	Removed from incubator 9th day
105	,, ,, ...	37°	,,	xx	xx	xx	xxx	
106	,, ,, ...	,,	,,	xx	xx	xx	xxx	
122	,, ,, ...	22°	March 2	—	x	x	x	,,
123	,, ,, ...	,,	,,	x	x	x	xx	,,
124	,, ,, ...	37°	,,	x	xx	xx	Sent	away
125	,, ,, ...	,,	,,	x	x	xx	xx	
126	,, ,, ...	,,	,,	x	x	xx	xx	
127	,, ,, ...	,,	,,	x	xx	xx	xx	
128	,, ,, ...	,,	,,	x	x	xx	xx	
116	Healthy breath (with mucus) .	22°	,,	x	x	x	xx	
117	,, ,, ...	37°	,,	x	xx	xx	xx	

TABLE VIII

No. of experiment	Media with fresh culture	Temperature	Date of inoculation	Period of cultivation				Remarks
				Two weeks	Four weeks	Two months	Three months	
	Lining wall paper, with vapours and ½ per cent. gelatine	Cent.						
98	Pure ground air	37°	Feb. 10	x	xx	xx	xx	
99	,, ,, ...	,,	,,	x	xx	xxx	xxx	
102	Healthy breath	,,	,,	xx	xx	xx	xx	
103	,, ,, ...	,,	,,	xx	xx	xx	xx	
	Same, without gelatine							
108	Pure ground air	22°	,,	x	xx	xx	xx	Removed from incubator 9th day
107	,, ,, ...	37°	,,	xx	xx	xx	xxx	
109	,, ,, ...	,,	,,	xx	xx	xx	xx	
110	,, ,, ...	,,	,,	xx	xx	xxx	xxx	
111	,, ,, ...	,,	,,	xx	xx	xx	xx	
112	,, ,, ...	22°	,,	xx	xx	xx	xx	,,
129	,, ,, ...	,,	Mar. 2	x	xx	xx	sent	away
130	,, ,, ...	,,	,,	x	xx	xx	xx	
134	,, ,, ...	,,	,,	x	xx	xx	xxx	
119	Healthy breath (with mucus) .	37°	,,	x	xx	xx	xx	
121	,, ,, ,, . .	,,	,,	x	xx	xx	xxx	
118	,, ,, ,, . .	22°	,,	—	x	x	xx	
120	,, ,, ,, . .	,,	,,	x	xx	xx	xx	
131	Pure ground air	37°	,,	x	xx	xxx	xxx	
132	,, ,, ...	,,	,,	x	xx	xx	xx	
133	,, ,, ...	,,	,,	x	xx	xx	xxx	
135	,, ,, ...	,,	,,	x	xx	xxx	xxx	

TABLE IX.—CONTROL CULTIVATIONS

No. of experiment	Media with fresh culture	Temperature	Date of inoculation	Periods of cultivation				Remarks
				Two weeks	Four weeks	Two months	Three months	
		Cent.						
113	Blood-serum	37°	Feb. 10	x	xxx	xxx	xxx	
114	Agar-peptone	„	„	x	x	x	x	
136	Blood-serum	„	Mar. 2	x	xxx	xxxx	xxxx	
137	„ „	22°	„	—	x	x	x	
138	Agar-peptone	37°	„	x ?	x	x	x	
139	„ „	22°	„	—	x	x	xx	
140	Gelatine peptone	„	„	—	—	—	—	
141	„ „	„	„	—	—	—	—	
142	Potato tubes	37°	„	x ?	x	x	xx	
143	„ „	„	„	x	xx	xxx	xxxx	
144	„ „	22°	„	—	x	x	x	
145	„ „	„	„	—	—	—	—	

in the last series there was free growth on the medium employed; on both kinds of paper and in all kinds of condensed fluid. Eleven of them were grown at a temperature of about 20° Cent. In only one instance was there complete failure (No. 101, vapour from healthy breath).

Most of the tubes were left intact in order that they might be inspected, if required; but Nos. 102, 103, 104, 118, 122, and 128 were removed, stained, and examined microscopically, in order to determine whether they were true cultures. This they proved to be.

Nos. 124 and 129, after two months' growth, were sent away to be inoculated into guinea-pigs, but both they and the original seed proved to be non-virulent.

Microscopic Examination.—All the specimens in which there appeared to have been any growth were submitted to microscopical examination. In all cases where there did not appear to have been a distinct growth the result was put down as 'nil,' even though a comparatively small number of bacilli might have been found.

These few bacilli might have come from the inoculation. It was not difficult to recognise the abundant growth of a true cultivation.

These examinations, however, gave remarkable results in some of the specimens grown upon paper. Many of the bacilli were very long, and a considerable number of them showed distinct branching. Others were knobbed at one end or at both ends, so that they looked like miniature 'life preservers.' In many of the specimens the culture seemed to have penetrated into the substance of the paper.

The bearing of these researches upon the subject of the prophylaxis against tuberculosis seems to be of much importance.

They prove that any one of the various organically charged vapours, whether coming from healthy or diseased lungs, from the air of cellars or from comparatively pure ground, forms an excellent cultivating medium for the bacillus of tubercle when kept away from the disinfecting influence of air and light.

This power of promoting its growth is particularly manifest when the supporting substance is common wall-paper; though it is quite apparent when very pure filter-paper is used.

It is further proved that, on these substances, the growth of the bacillus may take place at the ordinary temperatures of dwelling-rooms, and, hence, that there is no safety against the increase of

TABLE VI.—EFFECT OF EUCHLORINE ON TUBERCULOUS SPUTUM PREVIOUSLY DRIED.

No. of experiment	Date	Animal used	Seat of inoculation	Quantity of sputum	No. of days drying
48	April 1893	Guinea-pig	Skin of leg	$\frac{1}{8}$ c.cm.	16
47	"	"	"	"	16
46	"	"	"	"	16
53	"	"	"	"	16
9	June 1892	"	"	1 c.cm.	?
54	April 1893	"	"	$\frac{1}{8}$ c.cm.	16
52	"	"	"	"	16
1	May 1892	Rabbit	Peritoneum	1 c.cm.	?
5	June 1892	"	"	"	?

TABLE VII.—EFFECT OF EUCHLORINE ON PURE CULTIVATIONS

No. of experiment	Date	Animal used	Seat of inoculation	Quantity of sputum	No. of days drying
49	April 1893	Guinea-pig	Skin of leg	Under 2 c.mm.	16
50	"	"	"	"	"
57	"	"	"	"	"
51	"	"	"	"	"
55	"	"	"	"	"
56	"	"	"	"	"

TABLE VIII.—EFFECT OF SULPHUROUS ACID ON PURE

No. of experiment	Date	Animal used	Seat of inoculation	Quantity	No. of days drying
89	July 1893	Guinea-pig	Skin of leg	$\frac{1}{2}$ c.m.	13
90	"	"	"	"	13
88	"	"	"	"	9
91	"	"	"	"	13
86	"	"	"	"	9
87	"	"	"	"	—

(THREE SPECIMENS OF SPUTA FOUND VIRULENT IN CONTROL EXPERIMENTS WERE USED)

Application of euchlorine		Results		Remarks
Distance from place where gas was generated	Length of application	No. of days after inoculation	Degree of tuberculosis obtained	
10 feet	2 hours	23	O	In all these experiments it is doubtful whether the capsules were always carefully protected from sunlight, as they usually passed through several hands. It is therefore possible that even the few cases of immunity may be due to this cause and not to the disinfectant.
6 feet	,,	28	II	
1 foot	,,	46	II	
6 feet	,,	50	II	
?	,,	80	O	
12 feet	,,	97	IV	
1 foot	,,	118	IV	
?	,,	48	O	
?	,,	76	O	

OF BACILLUS TUBERCULOSIS HOMINIS PREVIOUSLY DRIED

Application of euchlorine		Results		Remarks
Distance from place where gas was generated	Length of application	No. of days after inoculation	Degree of tuberculosis obtained	
1 foot	2 hours	30	III	Grouping Tables VI. and VII. together it will be seen that out of 13 experiments on guinea-pigs tuberculosis was produced in 11 (77 per cent. failures).
6 feet	,,	34	III	
12 feet	,,	43	IV	
10 feet	,,	53	IV	
1 foot	,,	74	IV	
6 feet	,,	84	IV	

CULTIVATIONS OF BACILLUS TUBERCULOSIS HOMINIS PREVIOUSLY DRIED

Application of sulphurous acid		Results		Remarks
Distance from source	Length of application	No. of days after inoculation	Degree of tuberculosis obtained	
5 feet	4 hours	14	I	It is possible that during the time the glass capsules were out of the laboratory some may have been exposed to sunlight. A pound of sulphur was used for 325 cubic feet of space. In 66 per cent. of these experiments the sulphurous acid failed to disinfect.
7 feet	,,	14	I	
4 feet	,,	45	O	
6 feet	,,	45	O	
7 feet	,,	46	III	
5 feet	,,	46	IV	

TABLE IX.—EFFECT OF SOLUBLE PRODUCTS OF COMBUSTION

No. of experiment	Date	Animal used	Seat of inoculation	Quantity	No. of days drying
152	Feb. 1894	Guinea-pig	Skin of leg	$\frac{1}{8}$ c.cm.	1
155	,,	,,	,,	,,	2

TABLE X.—EFFECT OF CHLORINATED LIME SOLUTION (STRENGTH

No. of experiment	Date	Animal used	Seat of inoculation	Quantity	No. of days drying
189 II	March 1894	Guinea-pig	Skin of leg	$\frac{1}{8}$ c.cm.	35
190 II	,,	,,	,,	,,	35
191 II	,,	,,	,,	,,	35
192 II	,,	,,	,,	,,	35
154	Feb. 1894	,,	,,	$\frac{1}{4}$ c.cm.	2
153	,,	,,	,,	,,	2

TABLE XI.—EFFECT OF FILTERED CHLORINATED LIME SOLUTION

No. of experiment	Date	Animal used	Seat of inoculation	Quantity	No. of days drying
105	July 1893	Guinea-pig	Skin of leg	$\frac{1}{2}$ c.m.	14
102	,,	,,	,,	,,	14
103	,,	,,	,,	,,	14
101	,,	,,	,,	,,	14
106	,,	,,	,,	,,	14
104	,,	,,	,,	,,	14

ON TUBERCULOUS SPUTUM PREVIOUSLY DRIED

Application of solution		Results		Remarks
—	Length of application	No. of days after inoculation	Degree of tuberculosis obtained	
Solution full strength	3 hours	31	II	—
Solution full strength	1 hour, slow drying afterwards	33	III	100 per cent. of failure to disinfect

1–10 TO 1–100) ON TUBERCULOUS SPUTUM PREVIOUSLY DRIED

Chlorinated lime		Results		Remarks
Strength	Length of application	No. of days after inoculation	Degree of tuberculosis obtained	
$\frac{1}{10}$	1 minute	22	0	In all those experiments in which the sputum had been kept 35 days dry it was found that the control inoculations gave positive results. In two cases, 191 II and 192 II, the experiment with disinfected paper was made on one side of the body, and that with non-disinfected paper prepared in the same way on the other side of the body (see 191 I and 192 I, Table V.)
$\frac{1}{10}$	4 brushings	22	0	
$\frac{1}{10}$	,,	23	0	
$\frac{1}{10}$	,,	23	0	
$\frac{1}{10}$	5 minutes	33	0	
$\frac{1}{10}$	1 dipping, slow drying for 17 hours	57	0	

ON PURE CULTIVATIONS OF BACILLUS TUBERCULOSIS HOMINIS

Chlorinated lime		Results		Remarks
Strength	Length of application	No. of days after inoculation	Degree of tuberculosis obtained	
$\frac{1}{100}$	1 dipping, slow drying	11	0	
$\frac{1}{10}$	1 dipping, slow drying	25	—	
$\frac{1}{10}$	1 dipping, slow drying	33	0	
$\frac{1}{10}$	1 dipping, slow drying	36	0	
$\frac{1}{100}$	1 dipping, slow drying	36	0	
$\frac{1}{100}$	1 dipping, slow drying	42	0	No infection

the bacillus in ordinary living-rooms in which active tuberculous dust is present, and in which the natural disinfectants of the bacillus —namely, fresh air and light—are not present in sufficient amounts.

Inquiry VIII.—A further inquiry, on the action of certain disinfectants on the Bacillus of Tubercle, was undertaken by Professor Delépine and myself; and the results may have interest in regard to the other observations referred to in paragraph 21, p. 13.

The preceding tables (VI. to XI.) give briefly the results obtained. It will be seen from Table VI.: (*a*) that Euchlorine, as ordinarily used for disinfection, had a very partial influence upon tuberculous sputum. Out of nine specimens, thoroughly exposed to these fumes, only four were deprived of virulence; and their effect upon pure cultivations of the bacillus, as shown in Table VII., was entirely negative.

b. Sulphurous acid failed to disinfect pure cultures in four out of six experiments; as shown in Table VIII.

c. The soluble products of combustion also failed to disinfect tuberculous sputum in the two cases in which it was tried (Table IX.)

d. On the other hand, filtered chlorinated lime solution, in strengths of from $\frac{1}{10}$th to $\frac{1}{100}$th, completely disinfected both tuberculous sputum (Table X.) and pure cultivations (Table XI.)

This research has an important bearing upon the question of the Prevention of Tuberculosis (see Chapter VII., p. 58).

CHAPTER IV

BODILY PREDISPOSITION (NATURAL OR ACQUIRED)

UNDER this head, in most instances, it will not be necessary to do more than recite the conclusions that have already been sufficiently ascertained.

a. Hereditary weakness of constitution, or of organs of the body, has an undoubted influence, making their subjects peculiarly vulnerable to the bacillus of tubercle (Wilson Fox, 'Diseases of Lungs,' &c. Heredity of Phthisis, with references, p. 528).

b. Apart from hereditary predisposition, some persons are born with constitutions unusually susceptible to the disease, so that in them it runs its course with extreme rapidity. Certain of the bodily tissues, also, are more or less liable to the disease than others (Ancell, Fox, and others).

c. Certain races of mankind are thus peculiarly liable to tuberculosis; notably negroes, and many aboriginal tribes (Hirsch and others).

d. The bodies of some persons, originally not apparently susceptible, or not peculiarly susceptible, to tuberculosis, may become so after suffering from certain diseases, such as measles, enteric fever, diabetes, &c. (Wilson Fox, p. 341); syphilis, alcoholism, cancer (Professor Sidney Martin, 'Syst. of Med.' Vol. II. pp. 33, 34).

e. On the other hand, some people, after an attack of one disease, such as small-pox, or even enteric fever, become more resistant to tubercle and to other disorders than apparently they were before; a conclusion justified by their immunity to tuberculosis, while other members of the same family succumb to it (Wilson Fox, p. 548).

f. Partial immunity from the disease has also been claimed for persons subject to certain heart complaints, rickets, emphysema, &c. (Wilson Fox, p. 547).

g. Susceptibility to tubercle may be acquired by persons engaged in certain occupations, which involve stooping or constrained postures of the body (Headlam, Greenhow, Parkes, and others).

h. Susceptibility is also often acquired by persons who have suffered from other diseases of the lungs or pleura; or from external injuries, such as those affecting the joints, the skin, or other parts of the body (Wilson Fox, Baumgarten, and others).

i. This tendency is especially noticeable in persons who have been the subjects of irritations of the lungs, from 'dusts' of divers kinds (B. W. Richardson, Hall, Arlidge, and others).

k. It seems certain that pregnancy has a powerful influence, both in predisposing to the disease and in hastening its course. Dr. Wilson Fox gives statistics to prove this point (p. 924), and quotes Dr. Pollock's statement: 'Pregnancy is found to complicate, to develop, or to precipitate phthisis remarkably, and exerts a powerful influence from twenty to forty years of age, culminating at thirty.'

l. It has been shown by Fermi and Salsano ('Centralbl. f. B. und Path.' xii. 21) that injections of dextrose and lactic acid will render guinea-pigs and white mice susceptible to avian tuberculosis; and it is important to note that avian tubercle bacilli, repeatedly inoculated into guinea-pigs, which have been rendered susceptible by such injections, become virulent for normal guinea-pigs (Allbutt's 'Syst. of Med.' i. p. 552).

These experiments show that animals usually refractory may become susceptible under certain conditions. Hence the importance of a study of those conditions. The most refractory animals are the carnivora, dogs, cats, Algerian rats; also sheep, goats, horses (Delépine, Sidney Martin, and others).

m. However strong may be the hereditary tendency to tubercle, it does not follow that the families in question are necessarily doomed to the disease (Hermann Weber, Croonian Lectures for 1885).

I have myself observed several instances in which the progeny of consumptive parents, on one side or the other, have remained perfectly healthy, and the grandchildren also have shown no sign of the tuberculous taint.

n. It has been asserted that most cases of pleurisy with effusion, and all such cases as afterwards become phthisical, are primarily due to tubercle of the pleura, which usually spreads into the lungs.

On this point I venture to express my opinion, derived from the results of a long practice, both public and private.

Without denying thefrequency of primary tuber cular pleurisy I must record my experience that a large proportion of cases of pleurisy with effusion have been due to other causes; and that many of those that have afterwards proved to be tuberculous became so from subsequent infection; due mainly to the embarrass-

ment of the lung caused by the constraint of adhesions. I rely upon the evidence of a large number of cases of pleuritic effusion which have never become phthisical; and upon the fact that many of those which afterwards declared tubercle did not show any signs of the disease until many years after the original attack of pleurisy.

o. Similar remarks must be made respecting the cirrhotic, or so-called fibroid, diseases of the lungs.

It is well known how frequently these terminate in true phthisis, but, as I can testify from long observation of several such cases, and from post-mortem examinations, many escape the infection, to which the inelastic condition of the lungs undoubtedly exposes them.

p. There remains yet another class of persons who are especially exposed to the danger of tubercular infection from without—namely, the now somewhat large number of persons who, having had one attack of tubercular infection, are liable to be reinfected by virulent tuberculous dust.

I will venture to make a few remarks as to the probability of this accident, and to give some reasons for believing in reinfection in phthisis.

1. We have the certainty that primary infection must come, in most cases, from external sources; and hence there can be nothing improbable in a second infection, or in multiple infections, from similar surroundings.

2. The patient has already proved himself to be susceptible to the disease, *i.e.* vulnerable to the bacillus, and therefore he is probably more liable than others to the disease.

3. By reason of his first attack, also, he is especially prone to become, for a second time, the host of the invading parasite. His damaged lung is less elastic, and less provided with the natural safeguards against its lodgment. We may also presume that the anti-microbic influences of the body, whether phagocytic or anti-toxic, are weaker in him than in the generality of human beings.

4. It is almost certain that the primary source of infection was the unhealthy house, or some usual haunt of the patient, and when he returns to his former condition of life he will probably meet again with a contingent of the same enemy that made the first attack on his lungs.

5. There is abundant evidence already mentioned as to the existence of infected houses and infected workshops. Their existence makes it highly probable that the inhalation of the bacillus will take place again and again, and that it will be received into susceptible lungs.

6. The bacillus of tubercle is notoriously long-lived in the presence of respiratory impurity, polluted ground air, or other organic filth. The probability that the consumptive has left the specific microbe somewhere in the house in a virulent condition is therefore exceedingly strong.

7. It is a common experience of hospital physicians that cases of phthisis often deteriorate rapidly on their return home, after they had greatly improved in hospital, and had even shown signs of cure. This fact is, of course, open to the explanation that the fresh air, good food, and healthy surroundings of the hospital had kept the enemy at bay for a time; but that it had again advanced when the poor food and the unhealthy conditions of the dwelling had so far lowered the patient's vital power that he could no longer resist its attacks. No one can affirm that such a course as this is not in accordance with what we know of the natural progress of the disease; nevertheless, from the considerations just noted, it is at least as likely that the virus, instead of coming from within the body, has been derived from the infected atmosphere of the home. In some of these cases certain circumstances render the latter the most probable explanation.

8. In not a few instances the disease, instead of spreading in its usual fashion along the track of the absorbents, commences afresh in the opposite lung or in the larynx.

9. In other instances the patient does not return home at once on leaving the hospital, but goes to stay with friends in the country, with people who are as poor as or poorer than himself, where, indeed, the main difference between his own home and the place of his temporary sojourn is fresh country air. Whilst he is under these conditions he still continues well, and gains in weight; but after he finally returns home, and has remained there only a few weeks, the disease again breaks out, makes rapid progress, and soon comes to a fatal end.

10. In some of the cases, the interval between the return home and the fresh outbreak of the disease is from three to six weeks; about the usual incubation period of tubercular infection.

11. Lastly, it is fair to count the numerous cases which are known, after change of residence, to remain free from fresh outbreaks of the disease, as being for the most part instances of escape from further external infection.

If space allowed, I could adduce numerous cases in support of these views (see paper on Reinfection in Phthisis, 'Med. Chron.' Oct. 1892).

The conclusions to be drawn from the preceding propositions are :—

First, that the causes of susceptibility to tuberculosis are exceedingly numerous ; secondly, that even though it should be proved that the bacillus cannot find an entrance to the system without some preliminary injury to the tissues, yet the sources of such injury are so numerous that sooner or later a point of entrance is pretty sure to be found ; but, thirdly, in spite of these facts, the disease may always be warded off by proper care of the health, and by avoiding all possible sources of infection.

CHAPTER V

CHANNELS AND SOURCES OF INFECTION

THE bacillus of tubercle can make its way from without into the body by various channels, and, in most cases, its entrance is facilitated by previous injury of the parts.

1. *The Generative Organs.*—It is possible, though rare, for tuberculosis to be conveyed to the fœtus by the seminal fluid, or through the mother's system.

Cases are occasionally seen of undoubted congenital tubercular disease (Verneuil, 'Etudes sur la Tuberculose,' pp. 59–74 ; Researches by Landouzy and Martin, and others by Lannelongue and Niepce ; also paper by Queyrat and Lannelongue, 'Die neue Anschauung über die Natur der Tuberculose,' 'Deutsche Med. Woch.' 1883, No. 15, and one by Marchand, 'Ueber Entstehung und Heilbarkeit der Tuberculose,' 'Münch. Med. Woch.' 1888, Nos. 29, 30).

Such cases are, however, of extreme rarity. Straus speaks of 'la rarité extrême de la tuberculose chez les veaux et chez les animaux jeunes' (p. 323). Leudet states that he has never seen a case of fœtal or congenital tuberculosis, whether hereditary or acquired. Vallin speaks of it as so rare as not to be worth notice. Peters declares roundly that 'on ne naît pas tuberculeux mais tuberculisable.' Bollinger says, 'Die sogennannte congenitale Tuberculose so gut wie auszuschliessen ist' ('Münch. Med. Woch.' July 17, 1888, p. 486).

There is certainly nothing to justify Baumgarten's theory that most of the cases of tuberculosis are due to fœtal infection ; to germs of the disease which may, under certain circumstances, remain latent, even through the whole of life, without interfering with living functions in any observable degree. He even believes that it may pass through a generation, and be transferred from grandparents to grandchildren ('Lehrbuch der Path. Mycologie,' p. 631).

Baumgarten, in fact, places tuberculosis in the same category as syphilis and leprosy, and ascribes the greater part of its ravages

to hereditary descent. After the evidence to the contrary already cited, it is unnecessary to do more than mark the theory as untenable.

2. *The Skin.*—Tubercle may undoubtedly be inoculated into the skin, either through a purposely made abrasion or through a sore; but, in this case, it is usually arrested at the first lymphatic gland, and is then often discharged from the body by suppuration.

Numerous cases of this kind are on record; but I will venture to cite one that came under my own observation, as its nature was fully proved both microscopically and by experiments upon animals, and because there was evidence of mixed infection.

A young medical man made a post-mortem examination of a child who was proved to have died of localised tubercular peritonitis. Immediately afterwards he found that he had a slight abrasion on his left hand, over the carpal end of the metacarpal bone of the thumb. He at once cauterised this with lunar caustic, and afterwards treated it with carbolic acid. The sore did not heal, and, though he felt anxious about it, he experienced no decided symptoms until six days had passed over. He then began to feel very ill, became very faint, and fell into a state of extreme nervous tremor. He was taken for an hour or two to the hospital, and was there dosed with brandy, after which he was conveyed home in a cab. His temperature was then ascertained to be over 103°; he was put to bed, and still treated with stimulants. Shortly afterwards two patches of congestion were discovered in the left lung, at the back; and two days afterwards a superficial abscess appeared over the right tibia, and a reddened line of inflamed absorbents led from the wound on the wrist up to the left axilla. Some thickening of the lymphatic glands in this region was apparent, and there was tenderness on pressure.

A distinguished bacteriologist, who saw him at this time, regarded the case rather as one of streptococcic infection than as one of tubercle; and he was led to this opinion by the acuteness and rapid advance of the symptoms, his temperature having several times reached 105°.

After a day or two more, in fact, the fever subsided somewhat, and there was reason to hope that this diagnosis was correct; but, at the end of a fortnight from the inoculation, it became apparent that there was more behind. The glands in the axilla became more swollen; and it was necessary, after a few more days, to make a deep exploratory incision into the axilla. Pus was found at a depth of about two inches, and, upon microscopic examination, it

was found to contain tubercular bacilli associated with M. tetragonus. A portion of the pus inoculated into a guinea-pig produced distinct tubercular infection at the end of three weeks.

The wound was treated with iodoform in powder and in bougies; and fortunately, after a lapse of a few weeks, it took good ways; the patient entirely recovered; and, after a period of more than three years, he has never felt any ill effects from the poisoning.

There can be no doubt that most of the cases of strumous glands are the result of infection of external sores by tuberculous matter, material generally derived from phthisical sputum.

3. *The Gastro-intestinal Tract.*—Though there can be no doubt as to the possibility of contracting tubercle by consuming tuberculous food, great differences of opinion prevail as to the actual amount of danger from such consumption.

First, with regard to meat. Dr. Straus believes the danger from this source to be very slight, and speaks of it as 'negligeable' (p. 639).

On the other hand, many others, notably Dr. Behrend in England and M. Nocard in France, regard this as one of the most prolific sources of tubercular infection.

To some extent we may regard this question as set at rest by the Report of the Commission on this subject.

In this document, although no countenance is given to the more alarmist views respecting the danger from meats of different kinds, yet the opinion is expressed that 'it is probable that an appreciable part of the tuberculosis that affects man is obtained through his food,' especially when this is consumed 'in a raw or insufficiently cooked state' (Report, p. 20).

The Commissioners go on to say, 'There is reason to believe that tuberculous matter, when present in meat sold to the public, is more commonly due to contamination of the surface of meat with material derived from other diseased parts, than to disease of the meat itself.'

They show, further, that tuberculous matter is mainly found in the milk of cows when the udder has been invaded by tuberculous disease, seldom or never when the udder is not diseased.

Secondly, milk is, in fact, the chief source of danger of intestinal infection to human beings. The Commissioners say, 'Tuberculous matter in milk is exceptionally active in its operation upon animals fed either with the milk, or with dairy produce derived from it.'

No doubt the largest part of the tuberculosis which man obtains through his food is from milk containing tuberculous matter.

Most of the cases of tuberculosis conveyed by food are cases of abdominal disease; but it has been shown by Baumgarten and

others that the disease may lodge in the lungs, or even within the cranium, derived though it be from the food, or from inoculation.

Dr. Woodhead's inquiries, contained in the same Report, as to the influence of cooking upon tuberculous matter which may be present in meat or milk, brings out the difficulties that stand in the way of a thorough sterilisation of these articles of food; and they make it all the more essential that the recommendations of the Commission, as to supervision of dairies, &c., should be fully carried out.

Valuable researches have also been made upon feeding divers animals with tuberculous material by Professor Sidney Martin. The outcome of these experiments is very tersely given in his article on Tuberculosis in vol. ii. of the 'System of Medicine.'

The course of infection in the various animals is carefully traced, and may be studied in this article.

Amongst other important matter should be noted experiments on calves, showing that, in calves fed with tuberculous material, the pleura may be affected, even though the lung be quite healthy; and that in pigs and guinea-pigs infection may take place without any perceptible local lesion.

From other facts relating to men also, he concludes that 'tubercle bacilli may enter the body without producing a lesion in the mucous membrane; and that, even if one of the glands in connection with the gastro-intestinal tract become tuberculous, this may readily lead to disease of a distant part.'

With reference to the action of the bacillus, he remarks that it is possible 'that caseation is a specific action of the bacillus,' and that 'a chemical substance is secreted by the bacillus which kills the cells.'

4. *Infection through the Air-passages.*—Infection of the respiratory organs by means of tuberculous dust conveyed into them by polluted air is the most common of all the modes in which the bacillus is introduced into the body.

This statement is supported by a multitude of well-ascertained facts.

1. By direct experiments on animals which have been made to inhale tuberculous matter, and have in consequence developed the disease (Villemin, Schottelius, and others).

2. By the distribution of phthisis throughout the world, its association with densely populated communities, and the comparative immunity of spàrse populations (see Chapter II.)

3. The history of public institutions such as prisons, reformatories, workhouses, &c., before and after the introduction of efficient ventilation (see Parkes, Hirsch, Lombard, and others).

4. The mortality in the army and navy before and after the provision of sufficient air-space and ventilation in barracks, ships, &c. (see Report of the Royal Sanitary Commission of 1858, Farr).

5. The relative death-rates from phthisis amongst males and females respectively must again be quoted in this regard, as a proof of the influence of respiratory impurity in the air.

6. The observations of Cornet and others must also again be cited in this place to show the fact of the presence of virulent tuberculous dust in certain rooms.

7. The facts detailed in the paragraphs relating to 'reinfection in phthisis' must also be recalled (see p. 41).

8. Also the existence in most large towns of infected houses and infected areas (see Chapter II., p. 10).

Lastly, there remains to be considered the much-vexed but important question as to the possibility, or frequency, of transmission of the disease directly from one person to another by the medium of the breath.

The evidence respecting this point has been so carefully collected and so impartially summed up by Dr. Wilson Fox that it is unnecessary to do more than to add my own reasons for coming to an opinion upon it. His final conclusion is 'that the evidence as it stands shows that even if this possibility (of some contagion) has an authentic foundation, the extent and degree to which contagion ordinarily extends is singularly small' (p. 574).

It appears to me that this conclusion, at any rate so far as direct infection from mouth to mouth is concerned, is justified by the following considerations :—

a. That the statistical evidence for such infection is almost valueless. For it has been shown that the number of cases of supposed infection falls short of what it should be, even on the hypothesis that the disease is not contagious (see the result of the application of Dr. Longstaff's formula, in the 'Collective Investigation Record').

b. That most, if not all, the cases recorded are placed out of court by the impossibility of ascertaining that they were due to direct infection, and that they did not arise from the presence in the dwellings of tuberculous material under the form of dust.

c. That if phthisis be directly conveyed from person to person, it is difficult to see why it should be affected by the nature of the sub-

soil of dwellings; and why its prevalence should be so greatly diminished by a decrease in the wetness of soil.

d. That the influence of altitude upon the disease presents difficulties similar to the last.

e. That, if the simple contagion theory were true, hospitals for consumption should have been, at any rate in the past, centres and hotbeds of infection; but the universal testimony of physicians to these institutions is that no conveyance of the disease can be traced, in any such institution, even before the practice of disinfecting the sputa had been carried out.

f. That there is no satisfactory proof of infection direct or indirect in any well-ventilated house in this country; and that in spite of close contact, as in the case of attendance of a wife upon her husband, or in that of the nursing of near relatives and friends, or even in the case of the healthy and diseased sleeping together, no infection usually takes place in such houses.

Other observers, notably Drs. Andrew, Henry Bennet, Ricochon, Walshe, and C. T. Williams, have come to the same conclusion.

On the whole we may conclude with Hirsch, 'that contagious transmission of the disease plays but a subordinate part in the spread of the malady.'

Summary.—On reviewing the facts just given and taking also into account the relative mortality from different forms of tubercular disease, we are forced to the conclusions: (1) that the most common channel by which the bacillus of tubercle makes its way into the human body is the respiratory tract; and that the most common source of infection is tuberculous dust. This dust arises chiefly from tuberculous sputum, which has been allowed to dry up until it becomes pulverulent, and to remain in places where it is able to retain its virulence until it can reach the air-passages.

(2) Next in importance come the intestinal organs, and their absorbents, as the channels, and tuberculous food as the sources. In this case also tuberculous dust from the atmosphere probably plays an important part.

(3) As a channel, the skin perhaps comes next; and, as the source of infection, any form of tuberculous matter.

(4) Direct infection in the course of the generative processes is extremely rare; and (5) direct infection from the breath of phthisical persons is probably the rarest of all.

Mixed Infection.—Closely connected with the subject of infection by the tubercle bacillus come the questions: (*a*) whether other pathogenic microbes are usually associated with this bacillus; (*b*) whether some of the more urgent symptoms, at any rate of lung infection, may not be due to these associated organisms; and (*c*) whether any antitoxic treatment could be adopted with advantage in such cases?

a. Koch notes that, besides certain inoffensive saprophytes, such as the bacillus of green pus in old vomicæ, there are others associated with the bacillus of tubercle which are destructive, such as the micrococcus tetragonus.

Babes ('Congrès pour l'étude de la tuberculose': Paris, 1888, p. 542) has found, associated with the bacillus of tubercle, the pneumococcus, and, more rarely, Friedländer's bacillus pneumoniæ; the streptococcus aureus or albus; and the bacillus pyogenes fœtidus. He concludes that tuberculosis facilitates the invasion of other microbes, and that these, in turn, favour the dissemination of the tubercle bacillus, and so provoke acute attacks of tuberculosis, in chronic and latent cases.

Czaplewski ('Untersuch. des Auswurfs auf Tub.' Jena, 1891, p. 67) agrees with Babes. Cornet also believes in 'Mischinfection,' in which a chronic septicaemia is grafted upon tubercle; and Ziegler concurs with this opinion.

Marfan (art. 'Phthis. Pulm.' 'Traité de Méd. de Charcot,' &c. 1893) believes in a mixed infection by Fränkel's pneumococcus, Friedländer's diplococcus, and streptococcus pyogenes. He says: 'Le bacille de tubercule paraît envahir, sécondairement et en masse, un bloc hepatisé, où il trouve très probablement des conditions favorables.'

b. With regard to the influence of these immixed organisms, Strumpel ('Münch. Med. Woch.' 1892, p. 890) says, 'Most of the inflammatory outbreaks that are observed in the neighbourhood of tuberculous centres are the doing, not of the tubercle bacillus, but of the micrococci phlogogenes contained in the cavities; these common phlegmasic processes may be the principal causes of the fever of phthisis. The reabsorption of the soluble putrid septic products, massed together in cavities, also plays a certain part in the result.'

Maragliano ('Berl. Klin. Woch.' 1892, p. 268) thinks that hectic fever, loss of flesh and sweating come, not from the tubercle bacillus, but from foreign microbes—'septicémie chronique.'

Mosny and Aviragnet believe that in the broncho-pneumonias of tuberculous children these accidents are due, not to the bacillus of tubercle, but to divers other pathogenic organisms ('Thèses de

Paris,' 1891, p. 92), and Baumler ('Deutsche Med. Woch.' 1893) takes the same view.

Ortner ('Die Lungentuberculose als Mischinfection,' Wien, 1893) defends the same thesis by an appeal to morbid anatomy, and concludes that in the broncho-pneumonias of chronic phthisis it is the micrococcus pneumoniæ, and not the bacillus of tubercle, that is the pathogenic agent.

Petruschky ('Zeitsch. f. Hygien. Inf.' 1894, Band 17, p. 59) has repeated Kitasato's experiments, and affirms that he has found streptococci in tuberculous lungs. He believes that fever is lighted up when the purulent contents of a vomica stagnate and accumulate. When this empties itself, the fever ceases, as after the bursting of an abscess. Jakowski thinks that he has found both streptococci and staphylococci in the blood of patients during the hectic period; but this observation is not confirmed by Straus, who has repeated his experiments, and who gives reasons for disbelieving entirely in mixed infection (*op. cit.* p. 694).

c. With regard to the third point, viz. the possible use of antitoxines to mitigate at least some of the consequences of these mixed infections, we have, so far, the means of meeting the effects of only one of them—namely, the streptococcus.

An anti-streptococcus serum has been prepared, both in Paris and at the Institute of Preventive Medicine, and has been successfully used in various septicaemic disorders, such as puerperal fever, purulent infection, &c. It has also been used, with some success, in at least one case of phthisis; reducing the hectic fever, and relieving the general discomforts.

It is affirmed that the injection of this serum is quite innocuous; and, in case of failure of other means of combating high temperatures in phthisis, it appeared desirable to give it a trial after carefully pointing out to the patients and their friends the limitations of its possible usefulness.

Inquiry IX.—The following cases are given on account of their bearing upon the several questions above indicated; and also on account of the special care that was taken to demonstrate the reality of streptococcic infection in each case.

CASE I. was one of severe fever, in the course of acute phthisis, in a young lady (æt. 23).

The temperatures recorded for about three weeks were here given, but they were rather imperfectly and irregularly marked on the charts. The patient had been the subject of acute phthisis for about six months, and high temperatures were remarked by her

medical attendant a few weeks before. She had been treated by him with hypodermic injections of guaiacol daily, beginning with two minims and going on to ten minims. When I saw her, in consultation, she had taken, in addition, various antipyretics, and large doses of quinine, phenacetin, and antipyrin had been tried, with but little effect.

The sputum upon examination showed a fair number of bacilli; but what most attracted my attention was the abundance of streptococcic chains.

The case seemed to be a suitable one for trial of the streptococcus antitoxine, and a supply was obtained from the Institute of Preventive Medicine.

The sputum was further tested by the officials at the institute. A pure cultivation of the streptococcus, upon agar-agar, was obtained. The ear of a rabbit was also inoculated, and in six hours there was a marked and typical 'öhr-erysepel.'

The case was therefore regarded as one of active streptococcic infection; and if the fever were really due to this organism, and not to the tubercle bacillus, it might reasonably be expected that injections of the serum would at least modify its course.

Little, if any, effect upon the temperatures was produced by three injections of 10 c.c. each, at twelve-hour intervals. Later on, a similar amount of a still stronger serum was again used on three occasions; but it caused so much pain and distress that, after one more injection, the patient refused to undergo any further treatment of this kind. These latter injections were no more effectual than the former ones.

It is of course possible that the serum in this case was not used in quite sufficient quantities; but, so far as the experiment goes, it would seem to show that, in this case at any rate, the hectic fever was not chiefly due to the streptococcus, and that the serum was useless, even as a means of temporary benefit. She died about two months later.

Case II.—Mrs. G., æt. 35, two children; the last born in July 1896. Family history good. Personal history also good.

Shortly after her confinement she had a tooth extracted; and this was followed by an abscess in the jaw, from which a small spicule of bone was removed. Immediately after this she had a succession of rigors, with high and irregular temperatures; and at the same time it was discovered that she had pneumonia at the apex of the right lung. Sir W. B. saw her, in consultation with her own doctor; and, on being assured that the sputum had been examined,

and that no signs of tubercular mischief had been discovered (though only yellow elastic tissue had been sought for), he suggested that the case was one of 'septic pneumonia.'

The fever began about the middle of August 1896, and reached its height (105·4°) on September 5; but it lasted, with many irregularities, until October 4th. In the meantime a vomica formed in the right upper lobe, which ultimately destroyed nearly the whole of the lobe.

The fever then subsided into a regular hectic temperature, averaging 100° in the morning, and 101° in the evening; and when I first saw her, on November 19, it was highest at 6 P.M., and fell after this time. During this latter time she had regained some strength and weight; but, on examining the sputum, I found plenty of tubercle bacilli. The case was accordingly regarded as one of acute phthisis; but she continued to gain a little in weight, though the temperature, while normal in the morning, still rose to 101·4°, or even to 102·4°, at night.

A fortnight later, however, after another rigor, the irregular temperatures again commenced, and rose gradually until they again reached 105° on December 7, 10, and 12.

From the commencement of this attack it was recognised that a fresh outbreak of tubercular pneumonia had taken place, in the upper lobe of the left lung, and that there were also signs of pleurisy just above the left breast.

At this time the sputum was again examined; and, in addition to tubercle bacilli, numerous micrococci, single, in pairs, and in groups, were found; but, at this period, there were no chains.

Some of the sputum was collected in a sterilised bottle, after the patient's mouth had been well washed out with a boracic solution.

This was sown over night upon a tube of glycerine agar; and in the morning a pure cultivation of streptococcus was obtained.

For the fever, large doses of quinine, Warburg's tincture, and small doses of phenacetin were tried, without benefit; and inhalations of pure ozonised oxygen were given; but no impression was made upon the temperatures. After consultation with her medical attendant it was decided to propose to the family the use of the streptococcus antitoxine; and, although the limits of its usefulness were fully pointed out, they agreed to the trial being made. Accordingly the serum, obtained as before from the Institute of Preventive Medicine, was injected into the abdominal wall twice a day, in doses of first 10, and then 20 c.c.

After the fourth day the injection was made only once a day,

but, on the sixth day, an erythematous rash appeared on the upper part of the body, causing much irritation.

After the injections were commenced, the temperatures slowly but steadily fell, until, on the seventh morning, it almost reached the normal. It rose again that afternoon to 103·4° ; but a dose of phenacetin reduced it again to normal in the evening.

The rash was now so troublesome that it was thought best to give only one more injection of the serum ; and on the following night the temperature rose to 104·8°, showing that no permanent benefit had been derived from the treatment.

Two days after this she had another rigor, and almost immediately afterwards became collapsed, with extremely hurried breathing, blue lips and other signs of cyanosis.

She was now too ill to justify any auscultation, being, in fact, moribund ; but as percussion over the left side of the thorax was abnormally clear, it seemed probable that perforation had taken place.

She died twenty-four hours later.

In this case also, therefore, the antitoxine was productive of little or no benefit. Although there was a reduction of temperature, and of some of the discomfort arising therefrom, and although there was thus, perhaps, some proof that the fever was, partly at least, due to the streptococcus, yet no permanent benefit arose from the injections ; and I am by no means sure that the irritation of the erythematous rash was not a source of as great discomfort as the fever.

I have brought forward these cases mainly because of the light that they throw upon the question of mixed infection ; but they may also be of some service with regard to the question of treatment ; and, on account of their non-success, they may perhaps serve to warn practitioners of the inutility of the new treatment in cases of destructive lesions of the lungs, in which the intruding organism is continually being reproduced.

CHAPTER VI

THE CONDITIONS AND LIMITS OF INFECTIVENESS

THE preceding remarks will have prepared the way for the consideration of the circumstances under which infection by tubercle may take place. It will be well that they should be set forth in order.

1. The first essential for this infection is of course the presence of the bacillus in the body; and that it should have entered in sufficient numbers to overcome resisting impediments.

2. To this end, the microbe must have been in the presence of such conditions as enabled it to exist in a vigorous, active state.

In the rare cases of congenital tuberculosis, it may be assumed that this state has been maintained; in intestinal infection from food, that its virulence has not been destroyed by adequate cooking; but, in the case of infection from without, whether by inoculation, or by inhalation into the lungs in the breath, the bacillus must either have been recently shed in an active state, or it must have been kept alive, or even been enhanced in virulence, by surrounding conditions.

These conditions have already been noted, but they shall presently be briefly recapitulated.

3. Before attempting this, however, the axiom must be stated, that no infection can take place unless the bodily tissues are in such a condition as to receive, and to nourish into colonies, the bacilli which have found an entrance.

As we have seen (Chapter IV.), this condition is the result of a state of the bodily constitution; due to some predisposing weakness, hereditary or acquired.

4. It is doubtful whether an entrance of the bacillus is ever made through an unbroken or uninjured surface. The natural forces of resistance are probably almost always sufficient to stave off a genuine infection, except where some previous attack of inflammation has left either an abraded surface, or such a condition of the lung or of other parts as to permit the bacillus to rest until it can form colonies, the produce of which can enter the tissues.

It is thus that attacks of catarrh or limited pleurisies, or broncho-pneumonias, are of so much importance in the history of most cases of phthisis (*per contra*, see Chapter V., p. 47).

5. The more common conditions that preserve the vitality and virulence of the bacillus have already been pointed out, in the history of the distribution of the disease, and in the researches which have just been detailed (Chapter III.)

We can affirm, therefore, that wherever there are filthy surroundings, bad drainage, a polluted subsoil, an absence of sunlight, and, above all, an atmosphere polluted with respiratory and bodily emanations, there the chief danger of infection by tubercle is to be apprehended.

6. There remains the recapitulation of the several circumstances that have been found to destroy, to keep alive, or even to enhance the infective power of the bacillus of tubercle.

a. We have seen (Chapter III., Inquiry VI.) that sunlight, or even diffuse daylight, has the power of arresting the virulence of the bacillus; and that, under the healthy conditions of dry, pure subsoil, good drainage, and free ventilation, this arrest takes place too rapidly to allow tuberculous sputum to dry up and powder into dust before it is disinfected.

b. Free ventilation alone, even in the dark, when there is no great excess of organic matter in the air, has a decisive effect in reducing this virulence (Chapter III., Inquiry VI., p. 18).

c. But the bacillus can grow, and probably retain some of its evil power, even at ordinary temperatures, when it is kept moist with aqueous vapour containing a sufficient quantity of organic matter, derived either from the breath or from ground air (Chapter III., Inquiry VII.)

d. When kept away from light and air, in the presence of such material as has been mentioned, the bacillus will retain its virulence for many months; and it is difficult to destroy it by ordinary disinfectants, such as euchlorine or sulphur fumigations (Chapter III., Inquiry VIII.)

To sum up:—

(*a*) There is danger of infection by tubercle when a sufficient number of living and virulent bacilli can find an entrance into the body, and can overcome its powers of resistance.

(*b*) The danger is greatest when the body attacked is most susceptible, either by reason of bodily constitution, hereditary or otherwise, or when an increased susceptibility has been acquired in any of the ways enumerated in Chapter IV. But when the dose of the

virus is excessive the most healthy bodies may succumb to the attack.

(*c*) This danger is enhanced whenever the surrounding conditions are such as to keep alive or increase the virulence of the microbe. (These conditions are: badly drained and impure subsoils, ill-ventilated houses, workshops, or places of assembly, and the absence of sufficient sunlight.)

(*d*) There is always danger of inoculation of the virus through open wounds, or sores of the skin and mucous surfaces.

(*e*) Lastly, the danger of infection from imperfectly cooked tuberculous meat, or unboiled tuberculous milk, is always present wherever these foods are in use.

On the other hand, (*a*) there need be little or no fear of infection from the breath of a consumptive person. A few bacilli have occasionally been found in the aqueous vapour of the breath; but the number is far too small to constitute them a source of danger; and, as we have seen, there is no adequate proof that direct infection from the breath has ever taken place.

(*b*) Even phthisical sputum is not likely to prove infectious when freely exposed to sunlight and currents of pure air; and when it is not kept alive by impure vapours from the ground, or by emanations from animal bodies.

(*c*) The danger from tuberculous dust may be altogether obviated by preventing its formation, either through the immediate destruction or the disinfection of sputum, or by forestalling its drying up by washing it away, and by avoiding all places where it may exist in a virulent condition.

(*d*) The difficulty of avoiding the sources of the virus may be minimised by thorough disinfection, with solutions of chlorinated lime, of all rooms or workshops or other places where phthisical persons have lived, especially after a fatal issue of the disease.

(*e*) The bodily powers, in health, are capable of dealing with limited degrees of infection. It is important, therefore, that those powers should be kept at their highest point of efficiency, and that all predisposing injuries should be avoided.

(*f*) The danger of infection from tuberculous foods may be limited by the measures above described, and by others to be presently recommended.

(*g*) An open-air life is one of the best safeguards against the disease. Next after this comes a life spent partly in the open, and partly in well-lighted, well-drained, and well-ventilated dwellings.

CHAPTER VII

PREVENTIVE AND PROPHYLACTIC MEASURES

THE several methods by which not only persons predisposed to tubercle, but all mankind, may be preserved from contracting the disease, can readily be gathered from a consideration of the facts which have already been detailed.

I. It is obvious that, if the entrance of the bacillus from without can be prevented, there will remain to be dealt with only the very small number of cases of true congenital tubercle. Accordingly, our first duty is to stop the several sources from which the bacillus may spring, and to seal up the channels along which it may be conveyed.

a. In the case of tuberculous meat, we have only to enforce the recommendations of the Committee on tuberculosis by insisting that no meat from cattle affected by general tuberculosis shall be allowed to be sold for food.

Although the Committee did not consider that it was part of their duty to indicate the means of carrying out this restriction, it might doubtless be effected by the thorough inspection of cattle; by the systematic use of tuberculin as a test; by careful isolation and disinfection of suspected animals and suspected places; and by the removal of tuberculous animals to special slaughter-houses. In these, the necessary means might be provided for destroying or sterilising meat, without risk of contaminating healthy portions of the carcases.

At the present time, these recommendations of the Tuberculosis Committee cannot be fully carried out, by reason of defective legislative power and imperfect administration of the existing law.

The hygiene of cattle-sheds, for instance, in the direction of providing thorough ventilation, pure water supply, and the effective disinfection of stalls, &c., is even now partially carried out under

the Dairy and Milk Shops Order; but it ought to be much more stringently enforced, and veterinary inspectors ought to have more extended powers of entry into places where animals are kept.

The isolation of all suspected animals should be insisted on; their flesh or milk should not be allowed to serve as food for other animals, such as pigs, fowls, &c., and other precautions against infection should be taken.

Again, since tuberculosis is not included in the Contagious Diseases (Animals) Act of 1878, the veterinary inspector has no power to prevent the sale of diseased animals in the open market. This power ought to be given; and all animals which are at present exempt from slaughter, on landing from abroad, should be submitted to careful inspection, and, if necessary, condemned. If possible, also, breeding from tuberculous animals should be forbidden.

The powers and responsibilities of inspectors, in ordering the slaughter of diseased animals, should be the same for tuberculosis as for pleuro-pneumonia; and, lastly, the public should be instructed by the health authorities concerning the dangers arising from the eating of imperfectly sterilised meat or milk.

b. The danger of contracting tubercular disease from milk may, indeed, be obviated by boiling all milk; or by sterilising it, for half an hour, in a water-bath, at a temperature of 150° Fahr.; or, again, by securing, by means of the tuberculin test, and by thorough inspection, that no milk from tuberculous animals be placed on sale.

Professor Bang has shown that it is not difficult to render herds of cattle entirely free from tubercle: (*a*) by removing from the herds all animals that give a reaction with tuberculin; and (*b*) by keeping under supervision the calves of possibly tuberculous beasts.

Such measures are of extreme importance, both with regard to the protection of a community from tuberculous meat, and from the still greater dangers of tuberculous milk.

After all these precautions have been taken, however, the possible contamination of pure milk by tuberculous dust must also be averted by keeping the atmospheres of dairies, cowsheds, larders, cupboards, &c., free from this noxious material.

c. The next and most important, and certainly the most difficult task, is to prevent the entrance of the bacillus through the portals of the skin or the mucous surfaces, which takes place chiefly by means of polluted air containing the organism.

Doubtless, if it were possible to secure the effectual destruction

or disinfection of every particle of tuberculous matter, we might rest assured that, after a few months, no element of infection would remain to spread the disease. But under present conditions no such security can be attained.

In order to accomplish this work, it would be necessary to recognise each case of tuberculosis from its first inception, and to disinfect its products. But every medical man knows how subtle the disease is, and how stealthily it often makes its first advances, and how often its seeds are sown broadcast. The sputum of phthisis, the most common form of the disease, usually contains, even in its earliest stages, myriads of bacilli. We should also have to make sure that every affected person, even the most ignorant and careless, was thoroughly instructed in the proper methods of dealing with the material of the disease, and that he was certain to carry them out.

It is hardly necessary to say that not one of these essential conditions could possibly be observed, nevertheless it by no means follows that no effort should be made towards the disinfection of sputum. Every case in which this is done effectually diminishes by so much the risk of others contracting the disease, and the danger also of reinfection.

So far as contamination of the atmosphere is concerned, it is certainly hopeless to expect to keep it entirely free from the specific virus; but there remains to us a further means—namely, to see that the conditions of life which surround these dangerous persons are such as to secure the destruction of the virus before it can be transformed into tuberculous dust, and before it can be conveyed into the bodies of susceptible persons.

This task is almost as difficult to carry out as would be a complete disinfection of the air; yet it must be attempted, and, as in the case of disinfection, every effort will tend towards a diminution in the spread of the complaint.

We have seen that phthisis does not spread where there is pure air in abundance, where there is sufficient sunshine, and where the subsoil of dwellings is pure and dry (Chapter II.)

We have found that, under these conditions, even tuberculous sputum loses its virulence before it can dry up, and become transformed into dust sufficiently fine to be carried into the air (Chapter III.)

It is unlikely that we can ever secure these conditions for more than a very small modicum of the inhabitants of our large towns; but, on the other hand, we can see, in the diminution of the disease that has already taken place throughout the country, how large an

effect even a partial amelioration of their condition can produce (Chapter I., p. 3).

There is good reason, therefore, to hope for a favourable result both in regard to disinfection of tuberculous products and in the operation of general sanitary measures.

II. The special means to be used for the preservation of the air we breathe from contamination with the specific virus may be summed up under the heads : (*a*) notification of all cases of tuberculosis with discharging lesions ; (*b*) disinfection ; (*c*) hospitals ; (*d*) general sanitary reforms.

a. It is the opinion of some medical officers of health, notably of Dr. Niven, of Manchester, that even compulsory notification of tuberculosis is possible ; and Dr. Niven thinks that it should include not only cases of phthisis, but cases of abdominal tuberculosis, scrofulous cases, cases of caries with discharge, tuberculous diseases of the kidney and bladder, and all tuberculous ulcers with discharge ('Med. Chron.' October 1896).

Notification is indeed needed, so as to afford a means of closer investigation of the disease, and to ascertain the conditions attaching to the lives of those who have fallen victims to it ; especially in regard to the sanitary condition of the home or workshop.

It is also important as giving an opportunity of teaching the patient and his friends how to deal effectively with the discharges from his body. I do not, however, think that notification of phthisis should be compulsory. What is required is, that all cases likely to convey infection should be notified ; and it would probably suffice, for this purpose, if Poor Law medical officers, and medical attendants at all dispensaries, were to notify and receive a fee for every case in which bacilli were found. Local authorities should facilitate the bacillus search. A post-card, supplied by the medical officer of health and counter-signed by the patient, might then convey the necessary notice, and ask for disinfection. I may say that this plan has for a time been successfully carried out in one large northern town (Manchester) and in the City of New York, U.S.A.

b. Measures of disinfection are absolutely required in such cases. If necessary, they must be applied to the rooms which the patient inhabits, and in every case after his death.

It has already been noted that, for this purpose, the method of brushing all surfaces with a 1 per cent. solution of common chloride of lime is the best (Chapter III.)

The sputum of consumptive persons must be quickly destroyed, and must not be allowed to dry. Every patient should be instructed

to use a spitting cup, containing a 5 per cent. solution of carbolic acid or a weak solution of chlorinated lime, enough to cover the bottom; or, better still, a paper spittoon, that can be burnt, should be used.

Out of doors, a pocket spittoon, such as Dettweiler's, that can be scalded after using, should be employed. Small pieces of linen or calico, or Japanese paper, should be carried; and, if absolutely needful, may be used, and immediately burnt.

c. Hospitals also are required, not only for the curable cases, but in order to prevent the spread of disease, from patients suffering from phthisis, and other tubercular diseases, and in their most acute and infectious stages. After all efforts at thorough disinfection have been made, there will remain a large number of persons, actually suffering from these diseases, who will escape from the net of ordained precautions, and in their heedlessness, and contempt of danger to themselves and others, they will continue to spread abroad the seeds of tubercle, and thus susceptible individuals will continue to contract the complaint.

I would submit, therefore, that there should be a large increase in the number of beds available for these people, sanatoria for the different classes of patients, and special wards attached both to workhouse infirmaries and to hospitals belonging to local health authorities. All persons who are without proper lodging and accommodation, or who cannot, or will not, take the necessary measures for disinfecting and destroying the infective material, should be placed in these asylums.

d. Lastly, and most important of all, general sanitary measures are required. We have already seen how greatly the mortality from phthisis has diminished (p. 5); and from the coincidence of the fall with certain sanitary reforms we have concluded that most of the saving of life from this disease has been due to these measures. Assuredly it was not due to notification, disinfection, or isolation.

The most important of these reforms have been, undoubtedly, better drainage of the land and of towns, and improvements in the dwellings, calculated to permit the freer passage of air and sunlight around them and through them. It is accordingly in these two directions that we must still strive to advance.

1. For the protection of populations from the evil effects of impure ground air, it is essential that all local authorities should see to the thorough drainage of their districts; and that they should make sure that all dwellings are sufficiently protected against dampness and impurity of soil by concrete foundations, damp-proof courses, ventilation under the floors, &c.

The existing law is amply sufficient for these purposes, and most large towns have secured in their bye-laws the means of carrying out these plans. For the most part, however, these bye-laws apply only to new buildings; and the old parts of the towns, which supply the largest proportion of the phthisis death-rate, are still left in a dangerous and unhealthy condition. To deal effectively with these, the various Labourers' or Workmen's Dwellings Acts must be put in force with vigour, a course that is fraught with much difficulty and expense.

2. The other, and perhaps even more important, subject to which local authorities must pay urgent attention is the provision of free and thorough ventilation and access of light.

Viewed in relation to the prevention of phthisis, the subject of ventilation in its widest sense is a large and very difficult one. It involves not only the mechanical problem of admitting to living-rooms a sufficient number of cubic feet of the outer air, but it includes the removal of what has aptly been termed the 'air-sewage' from that air, and from the air of all places where human beings congregate. In the streets of towns there must be free course given to the winds of heaven; there must be no blind alleys or streets closed up at one end.

For these and other objects, local authorities will have to carry out extensive works of sanitary reconstruction, and will have to put in force the strongest powers they possess. Back-to-back houses and undrained and unaerated basements must be done away with; straight broad streets and open spaces for the circulation of air must be secured; and obstructions to air and sunlight, in the shape of many-storeyed houses, must not be permitted to exist.

Again, schools and other places of public assembly of all kinds must be supplied with a sufficient flow of air, in proportion to their temporary occupants; and workshops and factories must be adequately ventilated and freed from all irritating and pathogenic dusts. In a paper 'On the Ventilation of Schools' Sir Henry Roscoe has shown that 'our primary schools are, as regards healthy atmospheres, in a deplorable condition'; and he says, 'We must not rest until all our future elementary schools, to say nothing of the private schools, are ventilated by mechanical means.'

Dr. Arlidge, also, in his great work on 'The Diseases of Occupations,' points out that the defects in ventilation and in working space surpass, in their disastrous effects on the health of the employed, all other injurious conditions taken together. Scarcely any places

of employment are devoid of them, though they abound most in the workshops of mechanical trades, and in manufactories.

These defects are the more to be deplored, as they are distinctly remediable. Of late years, the skill of engineers has successfully developed efficient modes of ventilation, without draughts or annoyance to the workpeople; chiefly by the introduction of fans driven by gas or steam power. It may be hoped that the increased powers lodged in the hands of factory inspectors by the sanitary clauses of the Acts amended in the year 1891 may, by-and-by, insure the use of fans in all workshops where offensive or dusty operations are carried on. It is probable, however, that some additional legislation is required on this point.

But the defensive measures to be taken against phthisis must by no means be confined to the public authorities. Quite as much care must be taken by private individuals to protect themselves against breathing tuberculous dust. They must be warned not to live in damp houses, nor over damp or polluted subsoils; not to breathe air that has been already fouled by previous breathing or by filth of any kind, and not to close the living-rooms against the beneficial influence of direct sunlight. Hence the need of cleanliness and brightness in the house, soap and water washing, dusting, &c., &c., done in such a manner as not to add fresh evils to those of dirt, by merely stirring up or nourishing the microbes, and the daily flushing of rooms with constant currents of fresh outer air.

Ventilation as it is practised nowadays is often a mere sham. The inlets and outlets for air are usually far too small for the number of inmates, and the ventilation of most of our places of public assembly is a disgrace to modern science.

III. The next set of measures for the protection of individuals from the ravages of tubercle are concerned with rendering their bodies more resistant to its attacks.

We can scarcely hope to cause the 'materies morbi' to disappear entirely from amongst our crowded populations; but, as we have seen, man is naturally one of the more resistant animals; and if less than a certain dosage enters the body, the phagocytes, or some other influences, may prevent its lodgment, or its growth, to any serious extent.

Accordingly, attempts must be made (*a*) to improve the breed of our populations; (*b*) to forestall predispositions; and (*c*) to strengthen the weak to the resisting point.

a. It has already been admitted (Chapter IV., p. 39) that hereditary weakness of constitution, or of organs of the body, has

an undoubted influence in rendering their subjects peculiarly vulnerable by the bacillus of tubercle. The subject was not fully discussed, and I may perhaps express my own conviction that, by some authorities, this influence has been greatly over-estimated; but, in this place, it is sufficient to make the admission that it exists to some extent, and to pass on to the consideration of the means that can be adopted for minimising the dangers arising from this source; in other words, the measures that may be taken for improving the breed of our populations, so far at least as this tendency to tuberculosis is concerned. There are some persons who, whilst they admit that infection comes from without, yet believe so strongly in hereditary predisposition, that they hold that, until the bacillus can be banished altogether, marriage amongst those with a strong hereditary predisposition must be entirely prohibited.

Such prohibition, I believe, it would be quite impossible to enforce, and therefore it need not be seriously considered. The only thing that can be done with any prospect of success is to secure, by education, a healthy public opinion on the point. Fortunately, most intelligent people are already on our side. The heads of families are even now cautious in sanctioning marriages with individuals suspected of having a tuberculous family history. Medical men also, and ministers of religion, have much in their power, and may assist in discountenancing these marriages. But this is probably the utmost that can be done.

b. To forestall predispositions, on the other hand, is a much more practicable task. To some extent the acquirement of a susceptibility to the disease may be staved off; thus, many of the causes of catarrh, and of other more serious affections of the lungs, may be obviated; occupations that involve stooping or constrained postures during work may be improved, by the introduction of labour-saving machinery, and in other ways; and the irritating dusts arising from materials may be entirely swept away by means of fans, or by the use of moisture properly applied.

Again, although we cannot hope to get rid entirely of the baleful consequences of imperfectly cured injuries to the lungs, these lesions may be greatly reduced in frequency by appropriate treatment, and by increased care during convalescence from them. The treatment of convalescence from the weakening affections that have been shown (Chapter IV.) to predispose to tubercle must be carried out with especial reference to this source of danger, and all the precautions noted as necessary against infection must be taken.

I would point out especially that, after these diseases, a large

part of the subsequent danger from phthisis arises from the dread of 'catching' cold, the consequent confinement to close hot rooms, and the bad ventilation combined with lack of sunlight. It is often difficult to persuade patients that, after the first feverish stage is past, colds are not to be treated by keeping indoors, but by exposing their subjects, judiciously clothed, to pure outdoor atmospheres.

With reference to other forms of tuberculosis than phthisis, the greatest care must be taken in the treatment of all sores, so common in all delicate persons, especially children, about the orifices of the body, the nose, mouth, ears, anus, &c. They should always be treated antiseptically; and all skin eruptions must be dealt with as promptly and as thoroughly as possible.

During the cutting of the teeth, whether of the first or second set, when sores through which the bacillus may gain entrance to the system are very apt to form in the mouth, it is highly important that they should be early treated with antiseptic washes. The eruption of the first permanent teeth is especially prone to give rise to glandular swellings of a strumous character; and when any such swellings do form, they should be at once boldly and promptly treated, either by extirpation or, if they suppurate, by thorough scraping, and subsequent antiseptic treatment with iodoform or other effective germicides.

Imperfect development of the chest, or deformities, must be counteracted by judicious gymnastic and other athletic exercises, directed to strengthen the muscles of the chest, and to increase the power of expansion.

c. It is not necessary to say much respecting the means at our disposal for strengthening the bodies of susceptible persons against inroads of the tubercle bacillus. These means have already been admirably described by such Masters of our Art as Drs. Hermann Weber, C. T. Williams, Wilson Fox, and others. They are nearly all comprehended under the one word 'Hygiene.' They may be briefly summed up under the heads of residence in a healthy locality; situated, if possible, upon a dry and pure subsoil, elevated above the surrounding ground; abundance of nutritious easily digested food, with a large allowance of fats; an almost entirely open air life, with as much sunshine as can be obtained; suitable clothing, cleanliness, and bracing cold water ablutions; innocent amusements, and exercise without fatigue.

For the reason given, I shall not go into detail on these subjects. Certain observations, the results of a long and varied experience, may however be offered on one or two points.

First, as to the dwelling: I have already given sufficient evidence respecting the best sites for dwellings; but, even in the case of the best of sites, I am convinced that, where the disease has been contracted by any resident in the house, or even when it has been occupied at any time by a consumptive, it is desirable either *to change the residence*, or to have it thoroughly disinfected. It is always possible that the disease may have been due to some source of infection inherent in the house itself, some nook in which may lurk parcels of tuberculous dust, or to some emanation from the subsoil, some organically charged ground air, that may have kept alive, or nourished into virulence, the specific organism.

Next, as to abundant feeding. There can be no doubt that much may be done to strengthen the body against tubercle by careful and systematic feeding. Dr. Dettweiler says, 'Ma cuisine, c'est ma pharmacie.' In some cases even forced feeding may be necessary; but before having recourse to Dr. Débove's system of 'suralimentation,' or 'gavage,' which is somewhat unphysiological, I have been in the habit of trying careful artificial feeding, by means of nutrient and pancreatised enemata, and have several times adopted the Weir-Mitchell treatment with advantage, and have used a persistent course of massage, electricity, milk and other full feeding.

In many cases it is a great help to digestion and assimilation to insist upon rest, in the recumbent posture, and in the open air, for at least an hour after each full meal.

Again, with regard to indoor ventilation, I have for some time employed a method of my own for extemporising a capacious Tobins tube in any sash window. It consists in placing a sheet of strong plate-glass inside the window frame, and resting against the inner framework, not against the sash. It extends across the whole of the bottom of the window, and should be about fifteen inches in height. It can be readily fixed by the householder himself. The window can then be opened to any extent, from half an inch to a foot, and there are then left two spaces for the inlet or outlet of air, one at the bottom of the sash and the other between the two sashes; and yet there is little or no draught, for the incoming air current is directed upwards at either opening.

Lastly, a suitable climate is unquestionably a most important part of true hygiene; but this subject also has been so thoroughly discussed by men like Drs. Weber and Williams, who have almost made it their own, that I shall only briefly state that my own experience accords, in the main, with that of these observers, and

that the best results both in the cure and the prevention of phthisis have been obtained either by sea-voyages or by residence at high altitudes.

Perhaps I may also be allowed to point out a fact which has hitherto been little regarded by the bulk of medical men—namely, that exposed sea-side resorts are unsuitable for consumptive patients, especially when these places are situated on the littoral.

In my experience, the results of sending patients with tubercular disease of the lungs to any exposed seaside resort have been little short of disastrous. I do not profess to be able fully to account for this influence of strong sea air; perhaps it may be due to its highly stimulating qualities, or to its power of rapidly cooling the body, but of the fact I am strongly convinced. These remarks do not apply to places somewhat withdrawn, or sheltered from the sea breezes. I venture also to hold the view that mere climate, in the treatment of the tendency to phthisis, is of much less importance than certain conditions of environment, such as comfort, food, opportunities of living in the open air, medical supervision, &c.

The practice is much to be deprecated of sending patients away for mere change of climate, without any consideration of the above-mentioned points; especially of the last named. And yet it is an extremely common one. I have known of patients who were vaguely recommended to 'try the air of Switzerland,' or to go to California, or to the Cape, or to South Africa, without any further information as to where good accommodation, or enlightened medical supervision, could be obtained. I venture to assert that, both for the prophylaxis against and for the curative treatment of phthisis, the constant supervision of a well-instructed, enlightened medical man is of the utmost importance.[1]

With these few remarks I close the subject of the prevention and prophylactic treatment of tubercular affections. We shall next turn to its more systematic treatment.

[1] I beg to refer to Chapter II. for proof of the inefficacy of mere climate for the prevention of tubercular disease.

CHAPTER VIII

THE DIRECT TREATMENT OF PHTHISIS

(*a*) By 'Open Air.'—Closely allied to hygienic measures comes the special treatment of all stages of phthisis by means of constant exposure to almost open air, combined with a plenteous diet, judicious cold-water applications, and occasional 'massage.'

I have for several years pursued this method, so far as it was possible, in private practice; and the treatment at the hospital for consumption to which I was attached came very close to that by open air. The results obtained were very encouraging, but they could hardly be quoted as comparable with those obtained in properly equipped 'sanatoria.' With the exception of two houses in Bournemouth, recently established for the purpose, I do not, indeed, know of any sanatoria for this kind of treatment in Great Britain.

I have, however, recently paid a visit to several of the Swiss homes of this nature. I may, therefore, perhaps be allowed in this essay to give my impressions of the method, and of its results.

The treatment was originated many years ago by Brehmer, the founder of the Sanatorium of Görbersdorf, in Silesia; and the principles of the method may be briefly summed up under the following heads:—

(1) As regards the institution—a well-arranged building with a southern aspect; (2) placed upon a dry, pure, well-drained subsoil; (3) a pure atmosphere, with abundance of sunlight; (4) a garden, well protected from the wind; (5) sheltered verandahs, galleries, or arbours facing the sun; (6) constant and trained medical supervision; and (7) an adequate nursing staff. In addition to these essentials, there is, in Switzerland, the advantage of high mountain stations, from 4,000 to 6,000 feet in elevation, where the air in winter is remarkably dry, the sunshine abundant and warm, and the wind usually very little or none.

That the high altitudes are not really essential, however, is proved by the fact that there are several places, at much lower

levels (one, I know, not more than 200 feet above the level of the sea), where the results obtained have been just as favourable as those at greater elevations.

As regards the patients subjected to this 'cure,' the treatment involves (1) for many of them rest, in the recumbent posture during the greater part of the day, in the open galleries or other shelters; (2) careful and copious feeding; (3) massage in certain cases, in others carefully graduated exercises; (4) the judicious use of cold sponging, and other baths; (5) the provision of suitable amusements; (6) appropriate medicinal treatment.

At these establishments, all hygienic rules as to diet, efficient drainage, clothing, warmth in the living-rooms, good cooking, &c., are rigorously attended to, but it will be unnecessary to give all the details of the management, because this has been well described by Dr. Dettweiler, of Falkenstein, who is one of the chief apostles of the method, by Dr. Daremberg and others.[1]

It may suffice if I now state, as the result of my inquiry, that the treatment, in all its details, is fairly well carried out at Dr. Turban's establishment at Davos, and at the two great sanatoria at Leysin, at that time under Dr. Burnier's able superintendence. At one of the latter there is accommodation for 120, at the other for 80 patients, and the results in all classes of phthisical cases are truly surprising; great amelioration following in a large proportion of cases, and many persons deriving permanent benefit.

At Les Avants, also, above Montreux, there is a most excellent hotel, where the treatment is carried out chiefly under the superintendence of the English medical men resident at Montreux, one or other of whom visits the place on most days of the week.

Other establishments, such as those at Caux, near Territet Chillon, and Montana, above Sierre, are merely very good hotels at an altitude of about 4,000 feet above the sea-level. They have no resident medical attendants; and, owing to the prevalent fear of infection, they are not anxious to entertain phthisical patients.

This last-named fact is a great disadvantage to these places, as skilled medical supervision, constantly given, is of the utmost importance in this method of treatment.

The question must be put, what special advantages are to be expected from the exposure to the open air practised at these places

[1] Other writers on the subject are Dr. A. Moeller, 'Les Sanatoria pour le traitement de la phthisie'; Dr. Knopf, 'Les Sanatoria'; Dr. Léon Petit, 'Le Phthisique, et son Traitement Hygienique'; Dr. Duhourcau, 'Conditions Générales d'Installation d'un Sanatorium pour Tuberculeux.'

which cannot be obtained from our ordinary system of abundant ventilation?

I think it must be granted that a large part of the success of the treatment is to be ascribed to the hygienic measures, and to the watchfulness and care which are exercised by the attendants; but something may also be due to the 'hyper-aeration.'

In the first place we have, as Professor Pettenkofer has shown ('The Air in relation to Dwellings, Clothing, and Soil'), an enormous quantity of fresh, pure air passing over the bodies of patients in the open. This air is much purer than that of any living-room.

It has been ascertained that the number of micro-organisms, per cubic metre, is very much smaller outside than inside houses, however cleanly these may be; nay, the mere cleansing of a room will often materially increase the number of microbes floating about in the air. We may then with great probability explain the cessation of fever in our tuberculous patients, which we often observe after a short exposure to the treatment, to the almost total absence of streptococci or staphylococci. These organisms are very abundant in the sick-chamber; and they are almost always found associated with the tubercle bacillus in the lungs of phthisical patients.

Again, abundant fresh air, together with sunshine, acts antiseptically upon both the bodies and the clothing of patients, destroying all organic impurities which may emanate from either, and so purifying the air that enters the respiratory organs.

Further, the air of dwelling-rooms never contains an appreciable quantity of ozone. Therefore it may well be that only by the open-air method can we get the amount of active oxygen which is necessary to act medicinally upon the body, or which is sufficient to destroy bacteria.

Lastly, we must not forget the beneficial influence of sunlight.

The direct heat of the sun has, indeed, been found to be bad for patients, tending to cause fever and congestion of the lungs. But, on the other hand, De Renzi's experiments ('Nature,' May 25, 1895) show that sunshine materially assists guinea-pigs in combating tubercular disease. There can be no doubt, also, that sunshine purifies the air by its bactericidal action; and, as the experiments already given have shown (Chapter III.), it has an extremely rapid action in destroying the virulence of tuberculous sputum and tuberculous dust.

The warmth and the light of the sun, except in the height of summer, must quicken all the vital processes, and so increase the

activity of the phagocytes, especially, according to Metschnikoff, of the 'macrophages.'

Whatever may be the explanation of the results, there can be no doubt as to the greatness of the benefit derived from the treatment, when carried out fully, with open air and hygienic measures and medical care all combined.

I append a table of alleged results, given by Dr. Knopf, in his pamphlet. I have reason to believe that they are fairly trustworthy.

TABLE OF RESULTS

Sanatoria	Name of observer	Mortality	Cures		Ameliorations	Not ameliorated	No. of beds
			absolute	relative			
Falkenstein	Dettweiler	4–4·5	14	14	45	—	150
Görbersdorf	Achtermann	7·51	25		50–55	—	250
(Rompler)	Rompler	7·5	25–27		50	—	110
(Rüchler)	Wiecher	4·0	—		40	—	70
Reiboldsgrun	Wolff	2·5	—		70–73	—	100
Turban (Davos)	Turban	4·36	40		40	—	70
Hohenhonnef	Meissen	—	14·5–28·9		—	—	80
Nordrach	Walther	—	30		65	—	—
Halila (Finland)	Gabrilovitsch	13·5	36·7		33	16·7	—
Falkenstein (poor)	Nahm	—	13	—	77	10	—
Canigou	Sabourin	—	43·8		—	—	—
Adirondacks	Trudeau	—	20–25		30–35	—	—
Leysin	Burnier	—	—		—	—	200
St. Biasien	Haufe	—	-		—	—	160
Winyale U.S.A.	von Ruck	4·0	22·64		42·47	—	—

(*b*) BY OXYGEN AND OZONE.—Closely allied to the 'open air' treatment is that by inhalation of pure oxygen, or ozonised oxygen.

I have ventured to ascribe some of the good influence of fresh air to its contained ozone (p. 71); it was, in fact, the beneficial effect of abundant ventilation that led me, some years ago, to try the direct action both of pure oxygen, and of the same oxygen ozonised, as far as it was possible, by means of a Ruhmkorff coil and an ozonising tube.

Inquiry X.—The research was carried out in a large hospital for consumption, with the assistance of the then resident medical officer. Full particulars, with details of a representative group of cases, are given in the 'Medical Chronicle' (Vols. for 1888 and 1889).

A brief abstract of the inquiry may, however, be given in this place, and a statement of the conditions under which it was carried out.

In all modern hospitals for consumption the plan of providing an abundance of fresh air has no doubt been fully adopted, and has been very successful; but in hardly any other institution has it been so thoroughly practised as in the hospital in question.

In the new pavilion wards, enormous amounts of fresh air from open windows, and of air, also from the outside, but warmed by passing over hot-water pipes, were admitted.

Of the latter, if required, 18,000 cubic feet of air could be distributed through the wards per head per hour, and often was so distributed. It was ascertained also that the air, as it entered the warming apparatus, contained a fair amount of ozone.

In any attempt at comparison, therefore, the treatment by pure oxygen, or by ozonised oxygen, had to be placed in competition with that by abundance of ordinary free ventilation.

The oxygen used was supplied free of cost by Brin's Pure Oxygen Company.

When pure oxygen was administered, the inhalations were not given directly from the cylinders, but from a Clover's nitrous-oxide inhaler. After the bag had been filled with oxygen the current was shut off and the patient was allowed to exhaust the contained quantity, expiration being made into the external air through a valve opening outwards. The following notes were made on the action of pure oxygen, as supplied by Brin's Pure Oxygen Company:—

a. Pure Oxygen.—Three patients inhaled pure oxygen for periods of time, beginning with five minutes, gradually increasing to fifteen.

Case I.—K. W., phthisis, third stage, left; early second, right. She inhaled oxygen almost every day for four weeks in the manner stated above. The pulse and number of respirations were both diminished in number at the end of the experiments. These effects were very temporary, and were possibly exaggerated by nervousness. The patient said she felt clearer and lighter after each inhalation, and on two occasions a headache was cleared away. If taken just before a meal the appetite was improved. There was no effect perceptible upon the numbers of the bacilli in the sputum.

Case II.—S. H. In this case the left apex was breaking down, and the right lung showed slight consolidation in this region. Phthisis hereditary. The result of a week's inhalations was almost inappreciable; pulse and respirations unaffected; appetite slightly improved; there was the same feeling of clearness as in the previous case. The patient was usually sleepy after an inhalation.

Case III.—M. H. This patient's lungs were both in the stage of phthisis, the left being the more advanced. The pulse and

respirations were both increased at first, after inhalation; afterwards diminished. The patient was subject to headaches, which always disappeared after respiring oxygen, and she felt lighter and better. The respiratory power was distinctly increased for a short time. No effect could be observed upon the number of bacilli in the sputum.

In these three well-marked cases of phthisis the inhalations were never found to excite coughing unless the patients took deep inspirations. Deep inspirations ordinarily produced the same effect, and, on the whole, the progress of the disease was not found to have been affected by the inhalations. These experiments were therefore discontinued in favour of a trial of ozonised oxygen.

b. Ozone.—In the first instance it was thought desirable to ascertain the effect of ozonising the pure gas as it issued from the cylinders. It appeared possible that the deleterious effects of ozone, which had been at various times observed by others, might have been partly due to some impurity. Ozone was accordingly obtained by connecting the wires from an induction coil with the inner and outer tubes of an ozone-generator, and allowing a gentle stream of pure oxygen to pass through the tubes. The apparatus was at first placed in the ventilating chamber, underneath one of the pavilion wards. By means of test-papers, ozone could be found passing into the ward in increased quantity; but, as no appreciable results followed, and as atmospheric ozone was usually found in considerable quantities in the air from the outside, this method was soon discontinued. It was then tried in the 'sun-bath' upon several patients, but with unsatisfactory results; and a further trial in a small ward also led to no definite conclusions.

c. Pure Ozonised Oxygen under slight pressure.—It was now determined to try direct inhalations of the gas; but, as poisonous properties had been ascribed to ozone by divers observers, it was thought necessary, in the first place, to be very cautious in using it in a concentrated form. The resident medical officer and I tried, therefore, the effect of inhaling the ozonised oxygen after it had been passed into Tobold's gasometer, upon which more or less pressure could be made by means of weights. As we experienced no ill effects from our inhalations, the following cases were selected for cautiously graduated experiments with the gases.

A. J. E., aged forty-nine, of good family history, admitted October 10, 1887. His previous history was as follows: Winter cough since 1882, usually quite well in the summer. Last spring the cough increased; his breathing became shorter, and he lost flesh.

The expectoration became freer, and changed from being frothy, black, and white to a yellowish green. No hæmoptysis and no night sweats.

On admission it was found that the apex of the left lung was beginning to break down, but no definite signs of a cavity could be detected. Moist râles could be heard down to the base of the fifth dorsal spine behind. Bacilli found. After he had been in hospital seven weeks, during which time he gained about seven pounds in weight, he was given inhalations of the mixed gases under pressure.

(It was ascertained that about 8 per cent. of the oxygen was converted into ozone by the electric sparking. The Tobold's pneumatic apparatus was found to hold 562 cubic inches of gas.)

December 5.—The patient was given two inhalations under a pressure at first of three kilogrammes, and the amount was gradually increased to four inhalations daily at four kilogrammes pressure, during a period of five weeks. No difference was observed in the pulse, or in the number of respirations. The patient felt lighter and more buoyant, and after a few days could walk farther and with more comfort; he slept better and his appetite was markedly improved, especially for breakfast and tea. He gained in weight between five and six pounds. There was increased respiratory power, gauged by the lessening of the number of respirations needed to empty the gasometer. There was no catarrh, and at no time could any irritating effects be noticed. He never coughed, either at the beginning or end of the inhalation. The ordinary morning cough and expectoration diminished. At the end of the first week bacilli could not be found in the sputum, and when examined at intervals, four times subsequently, bacilli were still absent.

Case II.—B. H., æt. 29, had been admitted as an in-patient three months before this special treatment was commenced. He had a small cavity in the left apex and infiltration to four inches below the clavicle; and on the right side, under the upper three ribs, the lung was undergoing softening. He had already improved in health during his stay in hospital, and had gained nearly 13 lb. in weight. There was no fever and no night sweats, but bacilli were numerous in the sputum.

After three weeks' daily inhalations, emptying the gasometer twice or three times at a sitting, he expressed himself as feeling much better for the treatment. He still gained weight, and slept, ate, and breathed much better; the temperature remained normal, and the pulse had diminished in rate from 80 to 70. The sputum, however, still contained bacilli.

CASE III.—J. T. J., æt. 19, had phthisis in the second stage on the right and probably slight consolidation on the left side. He commenced the inhalations on January 20, having been in hospital ten days. His weight on January 20 was 110 lb., and on February 15 it was 115 lb. He emptied the gasometer daily from two to five times, under a pressure of four kilos, and seemed to have benefited from the treatment; his pulse had slowed somewhat; he ate and slept better, and his temperature became normal. His sputum on January 20 showed no bacilli, but on February 14 a few were found. On the whole, he gained 17 lb. in weight during eleven weeks in hospital, and afterwards, during a visit to Wales, he gained 10 lb. more.

These cases were deemed sufficiently favourable, and it was accordingly determined to give the treatment a more extended trial. During the following seven years, therefore, about sixty cases of phthisis were thus treated, in addition to the ordinary treatment of the hospital. Very little selection was made of the persons submitted to the inhalations, except that all obviously hopeless cases were excluded. All three stages of the disease were submitted to the treatment, and full notes of the first fifteen cases were taken. The details of these cases can be given, if required. I may state generally, that the average gain in weight of all the patients, in all stages of the disease, was upwards of 10 lb.; and although many of the cases, after their return home, again developed active disease, yet, whilst they remained under the treatment, in only one or two instances did the tubercular mischief make progress. Both before and since retiring from the hospital, I have also used the inhalations in private practice; but I have not found it necessary to employ the gasometer, as the quantity of the mixed gases used could very well be ascertained by means of a pressure-gauge; the only apparatus really needed being a dry battery or accumulator, a Ruhmkorff coil, an Ozonizer (made by the Electric Ozone Company), and a cylinder of Brin's Pure Oxygen.

I have never seen any ill effects arising from its use, but usually great benefit to the patients, especially to those who were at all anæmic. Although we have often had highly gratifying results from other treatment at the hospital, I do not remember any that were quite so satisfactory as in those cases in which this ozone was also used; such continuous freedom from fever, absence of night-sweats, diminution in the amount of expectoration, improvement in appetite and in sleeping power, and such consequent gain in weight and strength, and in the colour of the blood.

On the other hand, it must be pointed out that the ozone does not appear to have acted as a germicide; and therefore, that its control over the disease cannot have been, in the main, due to its bactericidal action. It is very doubtful whether even ozone could succeed in reaching the microbe in the consolidated exudations of phthisis; but it may well be that the gas may have a beneficial action upon the general health; that it may improve the condition of both the white and red corpuscles of the blood; and that it may enable the still healthy portions of the lungs to resist the noxious influences of the organism, and that it may thus ultimately cause the bacillus to die out of the parts already attacked.

CHAPTER IX

MEDICINAL TREATMENT

UNDER this heading, the plan adopted in the other portions of this Essay must again be followed; and many medicinal agents must be lightly passed over, with only slight references to my general experience of their utility. Only when I have distinct evidence to offer will any detailed notice be given.

It must not be assumed, however, from this course, that some of the modes of treatment thus passed over are not worthy of attention, nor that they should not have a further trial. I wish only to record, as briefly as possible, my own experience.

The following list gives the chief drugs whose administration I have watched, with short annotations.

a. Tuberculin (Koch's)	Tried upon twenty bacillary cases; reaction occurred in most; not in all. No diminution of disease, in most of the cases; several aggravated. One case of apparent recovery. Some evidence of danger.
b. Cantharidinate of potash, and chloride of gold.	No benefit; sundry unpleasant side consequences.
c. Iodol.	Not as good as iodoform.
d. Tannin.	After extensive trial, discontinued, owing to gastric troubles.
e. Iodine and iodides.	No specific effect; depressing.
f. Arsenic and iron.	No definite specific influence; useful for anæmia and for fattening.
g. Alkaline hypophosphites.	No definite specific influence; useful for anæmia and for fattening.
h. Vegetable bitters.	Useful as tonics and digestives.
i. Mineral waters.	Beneficial sometimes; partly owing to change of climate, &c.

k. The periodates.	No benefit.
l. Cod-liver oil, koumiss, &c.	Excellent foods.
m. Antiseptic inhalations.	Sometimes useful, no definite specific influence.
n. Hot air.	Tried without benefit.
o. Compressed air.	Tried with occasional benefit, especially when medicated with creasote.

In addition to these medicaments, I have made a careful study of the action of iodoform, and of creasote and its derivatives, and their compounds. On these points, therefore, I will venture more into detail.

Inquiry XI.—The action of iodoform, creasote, &c.

I have had a large experience in the use of iodoform for the treatment of several forms of tubercular disease. As an external application I have found it of great use in the treatment of scrofulous sores and abscesses, especially when it could be brought into immediate contact with the focus of the disease. I also began to give the drug internally, in cases of phthisis, about twelve years ago, trying it in all stages of the complaint, both in public and in private practice.

At first some disappointment was met with; many persons, especially women, were unable to take it, in consequence of the nausea and disturbance of the digestive organs that it caused. It was, however, given to all the cases that could take it, in the form of a pill, 1½ to 2 grains, three times a day; and presently I found that by combining with it a little codeia it could be taken without any difficulty.

In the observations upon the action of this and other drugs, the weights of the patients were recorded for some time before their employment, and after their administration. At the commencement of the research, charts were made, showing graphically the loss or gain in weight during the treatment; but the records upon which I chiefly relied were those relating to out-patients.

In-patients at hospitals for consumption are seldom good tests of the action of drugs. In my experience, so large a proportion of these persons do well, whatever course of medicine they are taking, that it is extremely difficult to discriminate between the improvement that is due simply to residence in hospital, and that which may rightly be ascribed to the treatment. In the out-patient department, on the other hand, large numbers of patients can be submitted to

observation, under all the otherwise unfavourable circumstances that usually surround them.

No selection of cases was made, the drug was given to nearly all the phthisical patients attending on my days; and, as patients seldom presented themselves at the dispensary in the incipient stages of the disease, the large majority of those who took the medicament were in the more advanced grades of the disorder. Occasionally, the administration of the drug was stopped for various reasons, and again recommenced; but, on the whole, the duration of the treatment extended over many months.

The chief effects which were noted were an improvement in the appetite, increased body-weight, and lessened cough. Its influence upon the weight was very marked. In the first stages a large proportion gained weight, often permanently. In the second, most of the cases gained flesh on first commencing the treatment; some of them lost again on discontinuing it, but, on the whole, there was a favourable balance. A total gain of from ten to twenty pounds was no uncommon event. In the most advanced cases there was often a temporary improvement on commencing the medicine; and, taking the whole series of several hundred cases, in more than 80 per cent. of them there was at least a temporary rise in the curve of weight immediately after the treatment was commenced or recommenced.

I am unable to make any estimate as to the proportion of cases even apparently cured; but I can affirm that there were several undoubted cases of bacillary consumption in whom the disease remained absolutely quiescent for from seven to eight years, and these were persons who were following their usual employments, and living in their own homes.

From a review of all the results I am inclined to attribute also to iodoform some improvement even in cases in which it was hopeless to expect a cure; and, in the earlier stages, I believe that it is one of the best medicines that can be given, both for the purpose of improving nutrition and of alleviating cough. I do not think that it has any 'anti-bacillary' action when administered internally; but it is probable that it assists the body in resisting further inroads of the bacillus.

CREASOTE.—ITS DERIVATIVES AND COMPOUNDS

Similar observations to those recorded for iodoform were made with creasote and its carbonate, with guaiacol and guaiacol carbonate. These were carried out in both in- and out-patient departments of the hospital, and in private practice.

Creasote was usually given to the patients in the form of simple emulsion with syrup of tolu and mucilage, and was rarely found to disagree. Latterly the commencing dose was five minims, three times a day, and this was increased as soon as possible to ten mimims.

I am bound to state that, on the whole, the results of this treatment fully confirm the favourable reports that have been given of its action by other observers.

In most of the cases in which creasote or its derivatives were given there was certainly often a distinct improvement, and there were several cases of undoubted arrest and apparent cure.

They all, even creasote itself, seemed to have a special action upon the stomach, improving the appetite, cleaning the tongue, and adding to the body-weight; and they also had some influence upon the secretions from the lungs, diminishing their amount and easing the cough. I cannot say that there was any evidence of direct action upon the bacilli in situ; but with the diminution or even cessation of expectoration there must have been a lessened discharge of the bacillus; there was also in many cases a decided improvement in the general health.

Creasote itself, dispensed as above described, was seldom found to disagree with the patients; and, latterly, we were not satisfied until the maximum limit of ten minims per dose was reached. It was often found that but little improvement took place until the dose had been raised to at least eight minims. The best results were obtained with the maximum dose persevered with regularly for long periods of time.

Certain observers, amongst whom is Dr. Daremberg, think that these large doses are hurtful, and that it is not possible for the system to take up much more than one gramme of creasote in the twenty-four hours; but our experience does not support this view, and recent researches have shown that several grammes can be absorbed per diem.

In some cases it is necessary to introduce the needful quantity by administering the carbonates of guaiacol or of creasote; but I have not often been obliged to resort to these compounds.

I do not propose to refer at length to the daily conduct of cases of tubercular disease, although this is probably the most important work of the attendant. Few complaints need so constant a supervision by a skilled observer.

I have also nothing special to report with respect to inhalations of various kinds, creasote, carbolic acid, eucalyptus, thymol, &c. These I have used freely, in common with most other medical men, but without any hope of destroying the bacillus in its intrenchments of exudation material, nor with any illusions as to their power of healing the lesions in the lungs. I am well convinced that the chief inhalant that can do real good is pure fresh air in abundance.

Inquiry XII.—There is, however, one course of special treatment which I have personally investigated, upon which my experience may be of some value. I allude to the treatment of abscesses in the lungs, whether tubercular or not, by intra-pulmonary injections.

A few of the cases admitted into our hospital for consumption seemed to be well suited for a trial of this method, and I have given a record of the results in full in my work on the treatment of phthisis (p. 178).[1]

[1] In the original Essay, this record was given in an Appendix.

CHAPTER X

CONCLUDING REMARKS

In the preceding essay I have perhaps sufficiently indicated my opinions as to the best means of controlling tuberculosis; but they may be briefly summarised here.

From Chapters I. and II. it may be gathered that the disease is both preventible and curable.

From the researches described, either fully or partially, in Chapter III., the nature of the materies morbi, and the conditions under which it retains or loses its virulence, may be ascertained; and, by my own original work, I claim to have explained the special incidence of the disease upon certain classes of the population, and upon certain unsanitary dwellings, and other places of human assembly.

I have shown, by actual experiment, with both pure cultivations of the tubercle bacillus and with tuberculous dust, derived from sputum, that the infecting material retains its virulence for long periods of time in these unsanitary places; and that it loses the power of infection, after exposure to perfectly pure air and to sunshine, for periods of time far too short for tuberculous sputum to dry up and become changed into dust.

On the other hand, by means of the experiments detailed in Inquiry VI., I have been able to show that, in the absence of ventilation and in partial darkness, the bacillus can grow freely, even at ordinary temperatures (not more than 20° Cent.), upon media such as are to be found in all badly ventilated houses—namely, impure aqueous vapours either from the ground air or from human breath. Common wall paper also was found to be an excellent aid to this cultivation.

The possibility of a saprophytic existence of the bacillus, and its ordinary conditions, have, therefore, been clearly demonstrated.

By means of these researches, and by inductions from the facts recorded in Chapters IV. and V., I have been able, to some extent, t

fix the limits, and to point out the conditions, of the power of infection by the bacillus of tubercle (Chapter VI.)

We have thus obtained a scientific basis for the measures advocated in Chapter VII. for the control of tuberculosis, in the direction of prevention and prophylaxis.

Many of the facts mentioned in the preceding sections have also a bearing upon the subjects discussed in Chapers VIII. and IX.—namely, the curative means best adapted for the general treatment of the disease, when fully established.

With regard to the relative value of the methods of treatment described in the last two sections, I do not wish to dogmatise; but it may readily be perceived that, for the complete extirpation of tuberculosis, I trust mainly to the thorough adoption of all the measures advocated in Chapter VII.

The statistics given in Chapter I. show clearly the effect already produced upon the disease, by even the imperfect sanitary reforms which have so far been carried out; and we may fairly look for its entire disappearance when the more perfect means already at our disposal are brought into play.

In the actual treatment of the disease, also, I am inclined to trust especially to those means, whether hygienic or medicinal, which increase to the utmost the natural resisting powers of the bodily system. In this regard, the research (Inquiry X., p. 72) upon the action of ozone may perhaps be of some use in calling attention to this powerful means of improving the condition of the blood, and assisting the general nutrition of the body.

Upon referring to the dates of the first experiments recorded in this research (p. 74), it will be found that I was probably the first to show by experiments upon myself the innocuousness of pure ozonised oxygen; and that I was also the first to use inhalations of this gas in the treatment of phthisis, both in hospital practice and upon private patients. The facts which I have noted in this Essay can be verified, if necessary, by an appeal to the hospital reports.

Inquiries VI., VII., VIII., and IX. are presented owing to their bearing upon several moot points in the natural history of tuberculosis.

Inquiry XI. is an addition to the detailed reports by other observers upon the action of drugs in tuberculosis, and Inquiry XII. records my experience of the treatment of pulmonary abscesses by intra-pulmonary injections.

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